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Nam et al.

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(54) **SYSTEMS AND METHODS FOR DYNAMIC AGGREGATION OF DATA AND MINIMIZATION OF DATA LOSS**

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(51) **Int. Cl.**
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G06F 11/30 (2006.01)
G06F 11/14 (2006.01)
G06F 16/906 (2019.01)
G06F 16/25 (2019.01)

(52) **U.S. Cl.**
CPC ***G06F 11/3075*** (2013.01); ***G06F 11/1471*** (2013.01); ***G06F 11/3068*** (2013.01); ***G06F 16/258*** (2019.01); ***G06F 16/906*** (2019.01)

(58) **Field of Classification Search**
CPC G06F 11/3068; G06F 11/3072; G06F 11/3075; G06F 11/3082; G06F 11/3086
See application file for complete search history.

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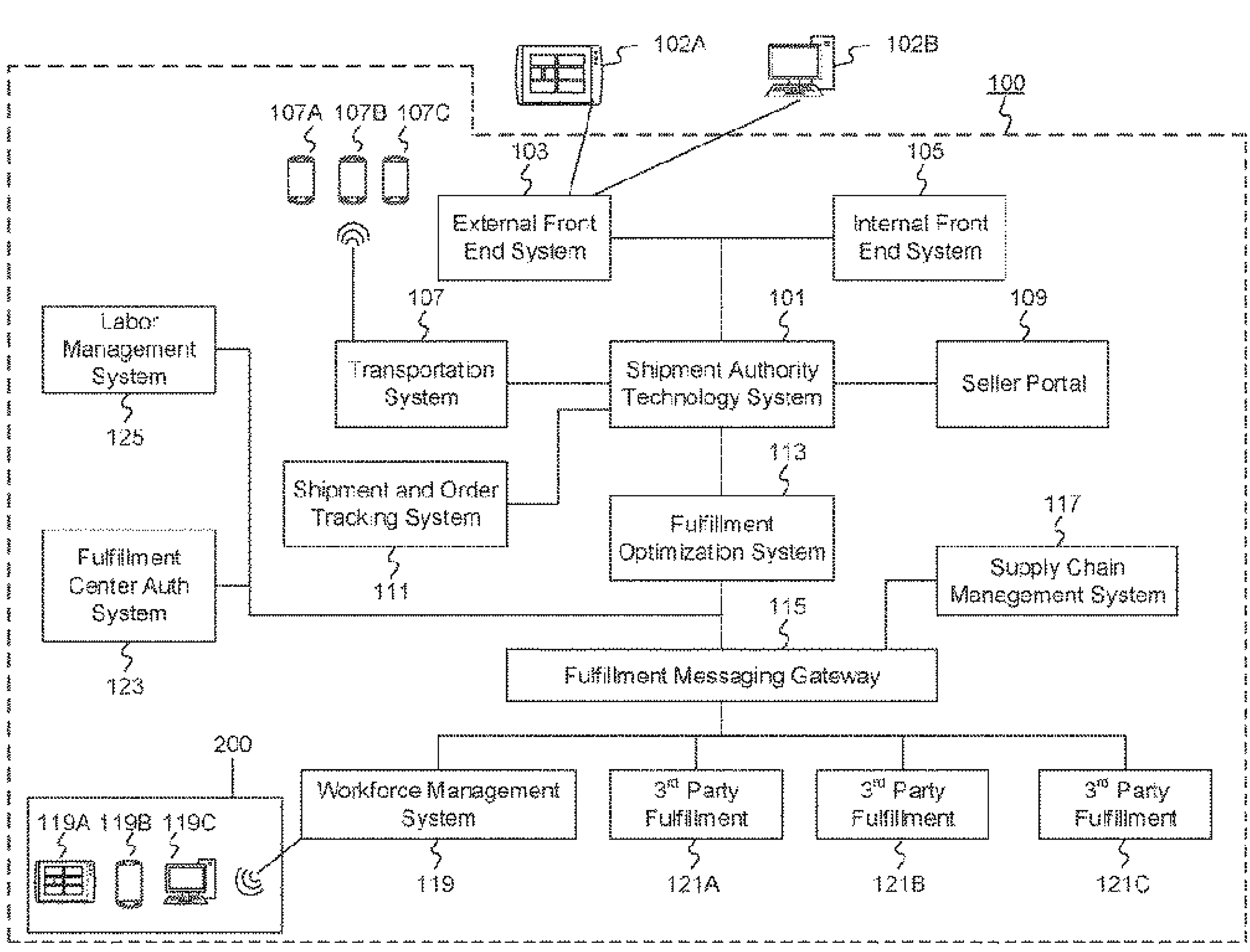
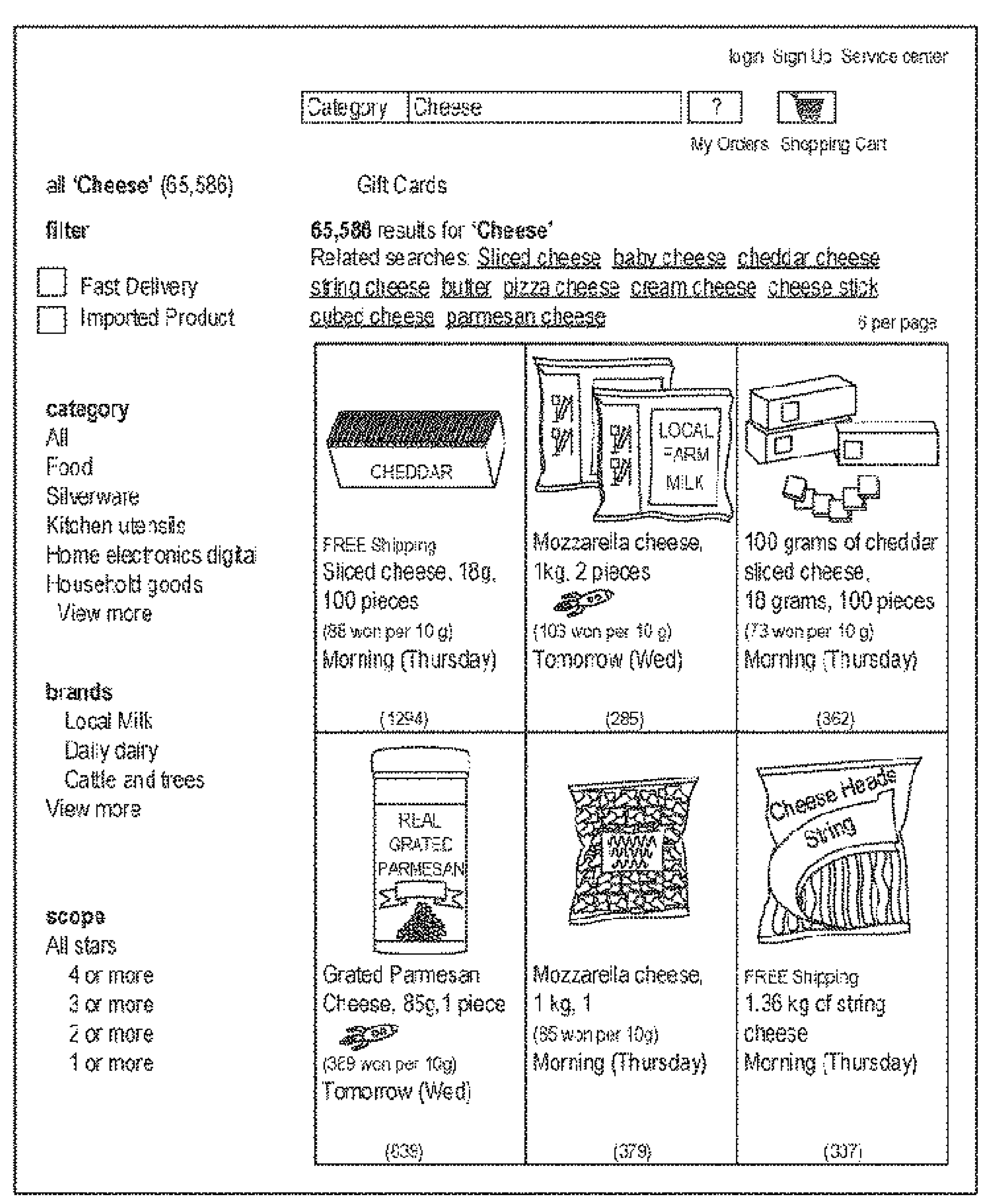
(57) **ABSTRACT**

A computer-implemented system for dynamic aggregation of data and minimization of data loss is disclosed. The system may be configured to perform instructions for: aggregating information from a plurality of networked systems by collecting a set of data from the networked systems, the set of data comprising data associated with a predetermined period of time and comprising one or more central variables that are included in data associated with more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables; retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables; and aggregating the first set of data into one or more master data structures corresponding to the central variables based on the data transformation rules.

18 Claims, 10 Drawing Sheets





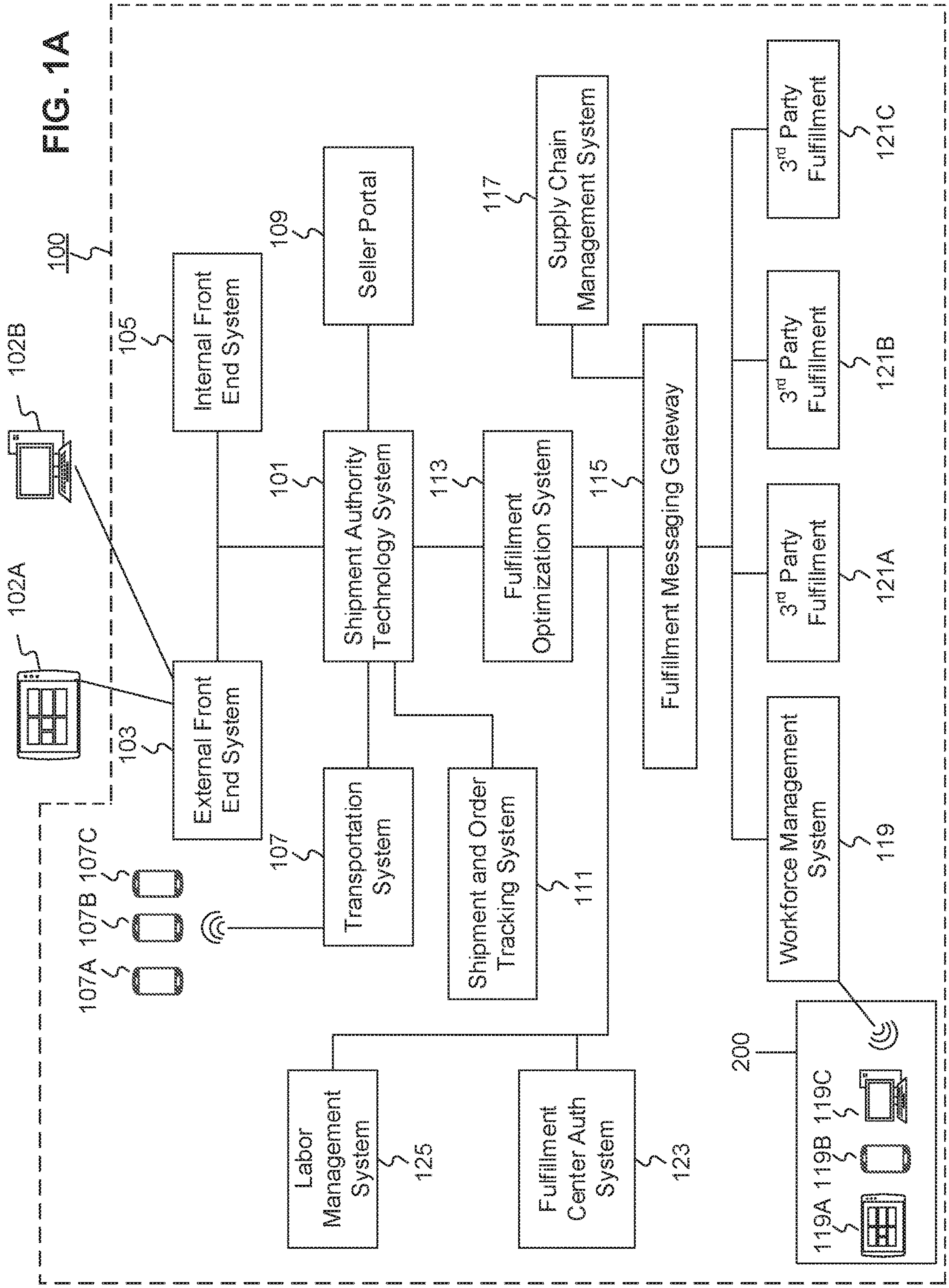

100
102A
102B
103
External Front End System
105
Internal Front End System
101
Shipment Authority Technology System
109
Seller Portal
107
Transportation System
107A 107B 107C
111
Shipment and Order Tracking System
113
Fulfillment Optimization System
117
Supply Chain Management System
115
Fulfillment Messaging Gateway
119
Workforce Management System
121A
3rd Party Fulfillment
121B
3rd Party Fulfillment
121C
3rd Party Fulfillment
200
119A 119B 119C
123
Fulfillment Center Auth System
125
Labor Management System

FIG. 1A

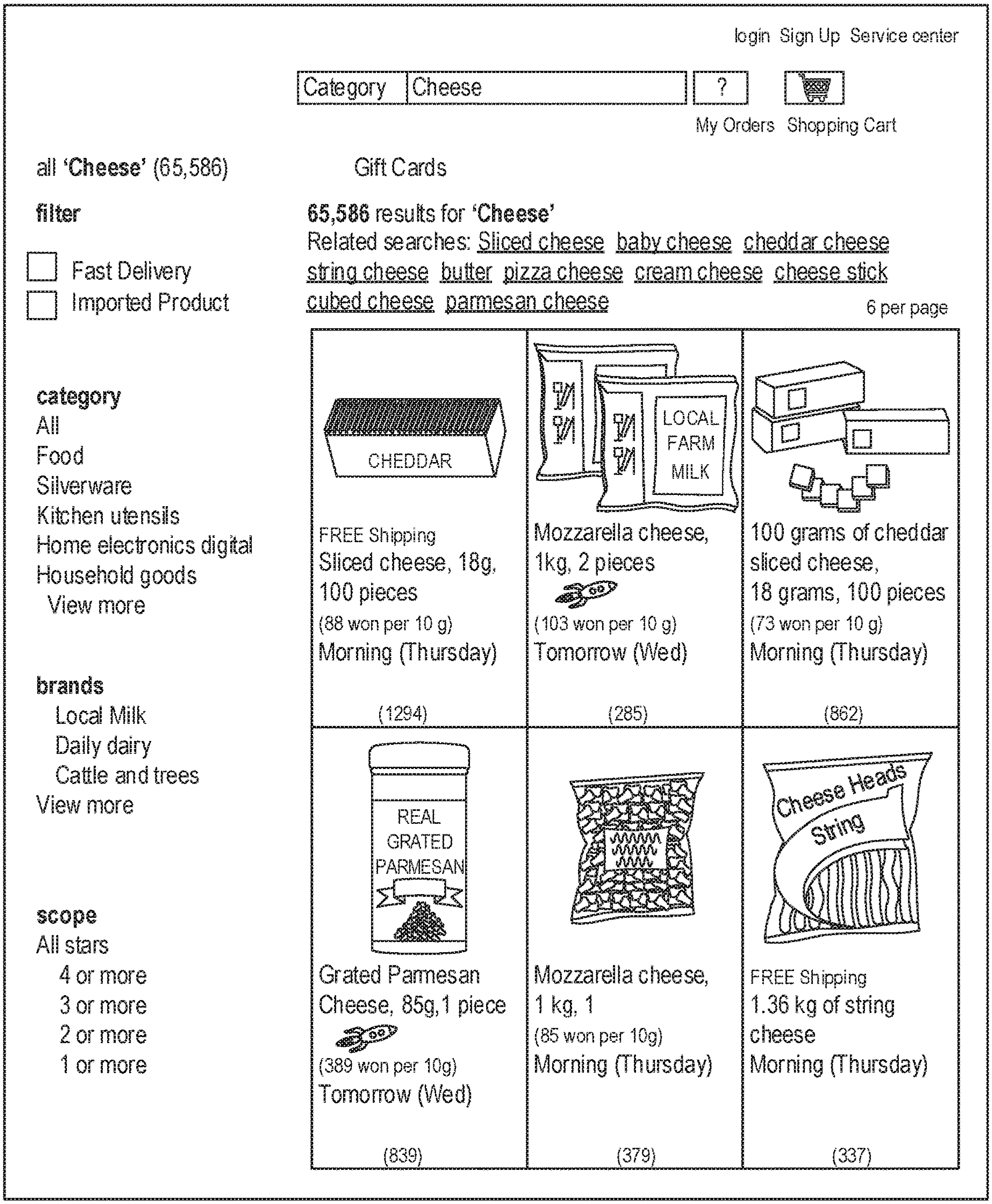

login Sign Up Service center
Category
Cheese
?
My Orders
Shopping Cart
all 'Cheese' (65,586)
Gift Cards
filter
Fast Delivery
Imported Product
65,586 results for 'Cheese'
Related searches: Sliced cheese baby cheese cheddar cheese string cheese butter pizza cheese cream cheese cheese stick cubed cheese parmesan cheese
6 per page
category
All
Food
Silverware
Kitchen utensils
Home electronics digital
Household goods
View more
brands
Local Milk
Daily dairy
Cattle and trees
View more
scope
All stars
4 or more
3 or more
2 or more
1 or more
CHEDDAR
FREE Shipping
Sliced cheese, 18g, 100 pieces
(88 won per 10 g)
Morning (Thursday)
(1294)
LOCAL FARM MILK
Mozzarella cheese, 1kg, 2 pieces
(103 won per 10 g)
Tomorrow (Wed)
(285)
100 grams of cheddar sliced cheese, 18 grams, 100 pieces
(73 won per 10 g)
Morning (Thursday)
(862)
REAL GRATED PARMESAN
Grated Parmesan Cheese, 85g,1 piece
(389 won per 10g)
Tomorrow (Wed)
(839)
Mozzarella cheese, 1 kg, 1
(85 won per 10g)
Morning (Thursday)
(379)
Cheese Heads String
FREE Shipping
1.36 kg of string cheese
Morning (Thursday)
(337)

FIG. 1B

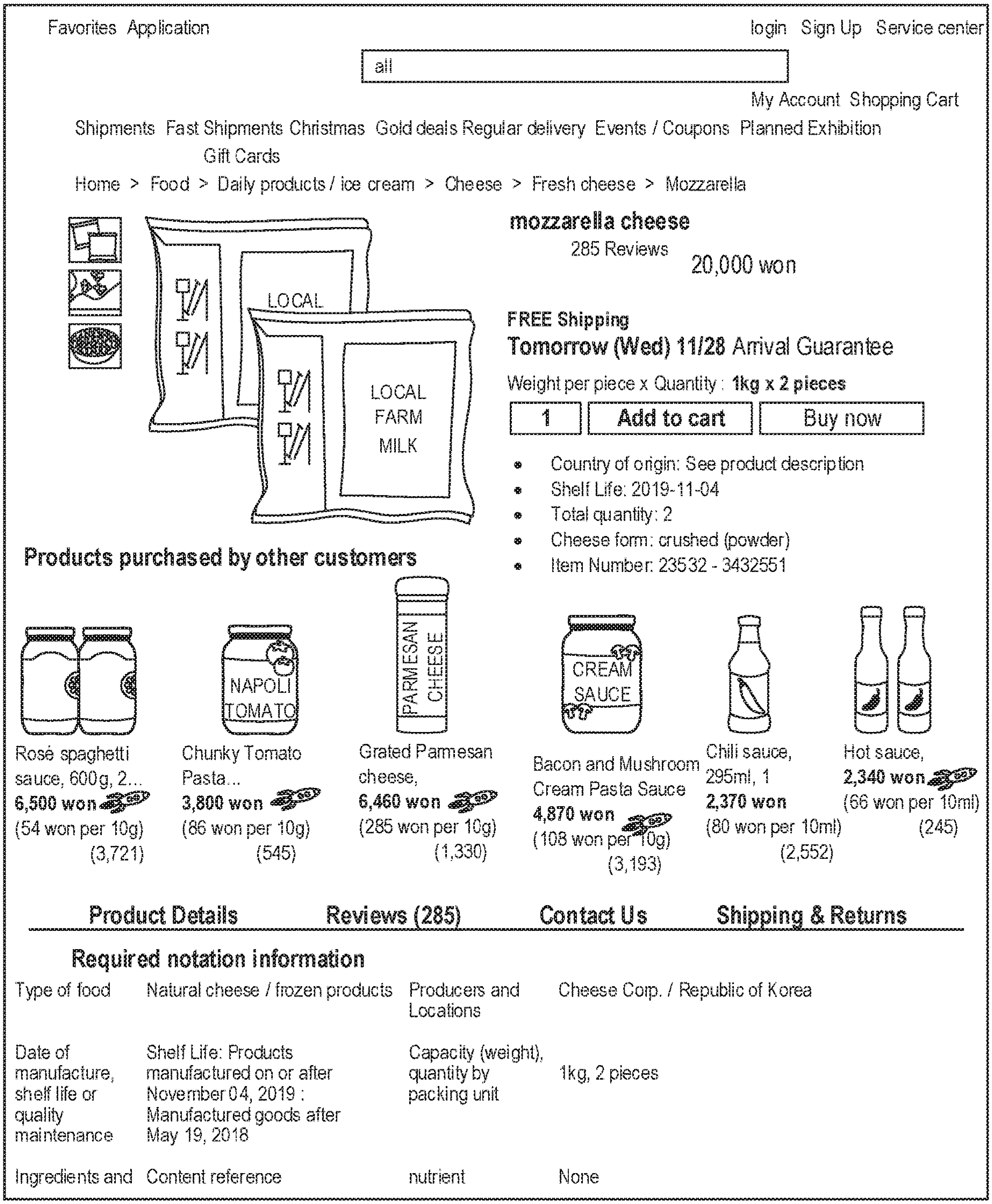

Favorites Application
login Sign Up Service center
all
My Account Shopping Cart
Shipments Fast Shipments Christmas Gold deals Regular delivery Events / Coupons Planned Exhibition
Gift Cards
Home > Food > Daily products / ice cream > Cheese > Fresh cheese > Mozzarella
LOCAL
LOCAL FARM MILK
mozzarella cheese
285 Reviews
20,000 won
FREE Shipping
Tomorrow (Wed) 11/28 Arrival Guarantee
Weight per piece x Quantity : 1kg x 2 pieces
1
Add to cart
Buy now
Country of origin: See product description
Shelf Life: 2019-11-04
Total quantity: 2
Cheese form: crushed (powder)
Item Number: 23532 - 3432551
Products purchased by other customers
NAPOLI TOMATO
PARMESAN CHEESE
CREAM SAUCE
Rosé spaghetti sauce, 600g, 2... 6,500 won (54 won per 10g) (3,721)
Chunky Tomato Pasta... 3,800 won (86 won per 10g) (545)
Grated Parmesan cheese, 6,460 won (285 won per 10g) (1,330)
Bacon and Mushroom Cream Pasta Sauce 4,870 won (108 won per 10g) (3,193)
Chili sauce, 295ml, 1 2,370 won (80 won per 10ml) (2,552)
Hot sauce, 2,340 won (66 won per 10ml) (245)
Product Details
Reviews (285)
Contact Us
Shipping & Returns
Required notation information
Type of food
Natural cheese / frozen products
Producers and Locations
Cheese Corp. / Republic of Korea
Date of manufacture, shelf life or quality maintenance
Shelf Life: Products manufactured on or after November 04, 2019 : Manufactured goods after May 19, 2018
Capacity (weight), quantity by packing unit
1kg, 2 pieces
Ingredients and
Content reference
nutrient
None

FIG. 1C

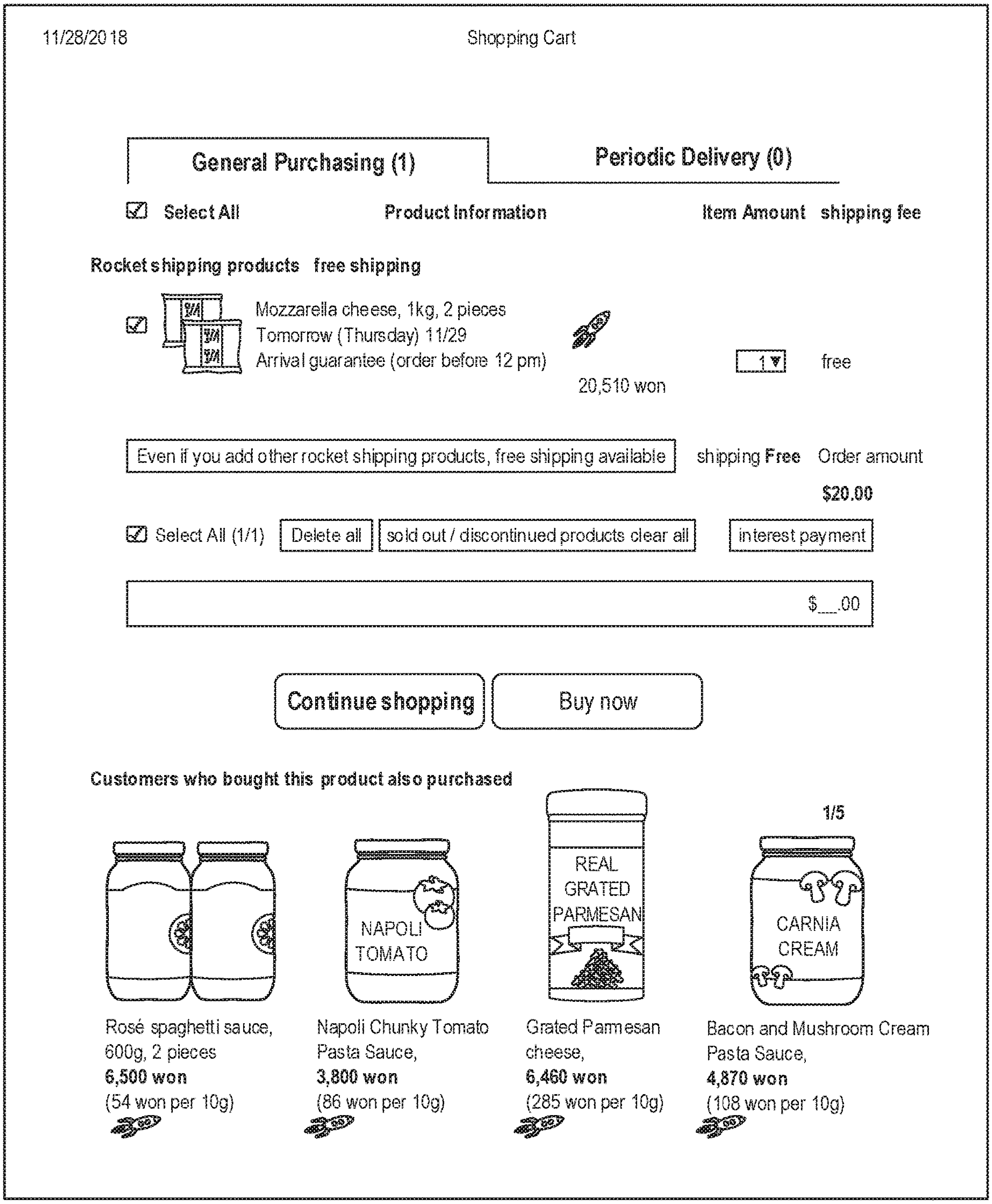

11/28/2018
Shopping Cart
General Purchasing (1)
Periodic Delivery (0)
Select All
Product Information
Item Amount
shipping fee
Rocket shipping products free shipping
Mozzarella cheese, 1kg, 2 pieces
Tomorrow (Thursday) 11/29
Arrival guarantee (order before 12 pm)
20,510 won
1
free
Even if you add other rocket shipping products, free shipping available
shipping Free
Order amount
$20.00
Select All (1/1)
Delete all
sold out / discontinued products clear all
interest payment
$___.00
Continue shopping
Buy now
Customers who bought this product also purchased
1/5
NAPOLI TOMATO
REAL GRATED PARMESAN
CARNIA CREAM
Rosé spaghetti sauce, 600g, 2 pieces
6,500 won
(54 won per 10g)
Napoli Chunky Tomato Pasta Sauce,
3,800 won
(86 won per 10g)
Grated Parmesan cheese,
6,460 won
(285 won per 10g)
Bacon and Mushroom Cream Pasta Sauce,
4,870 won
(108 won per 10g)

FIG. 1D

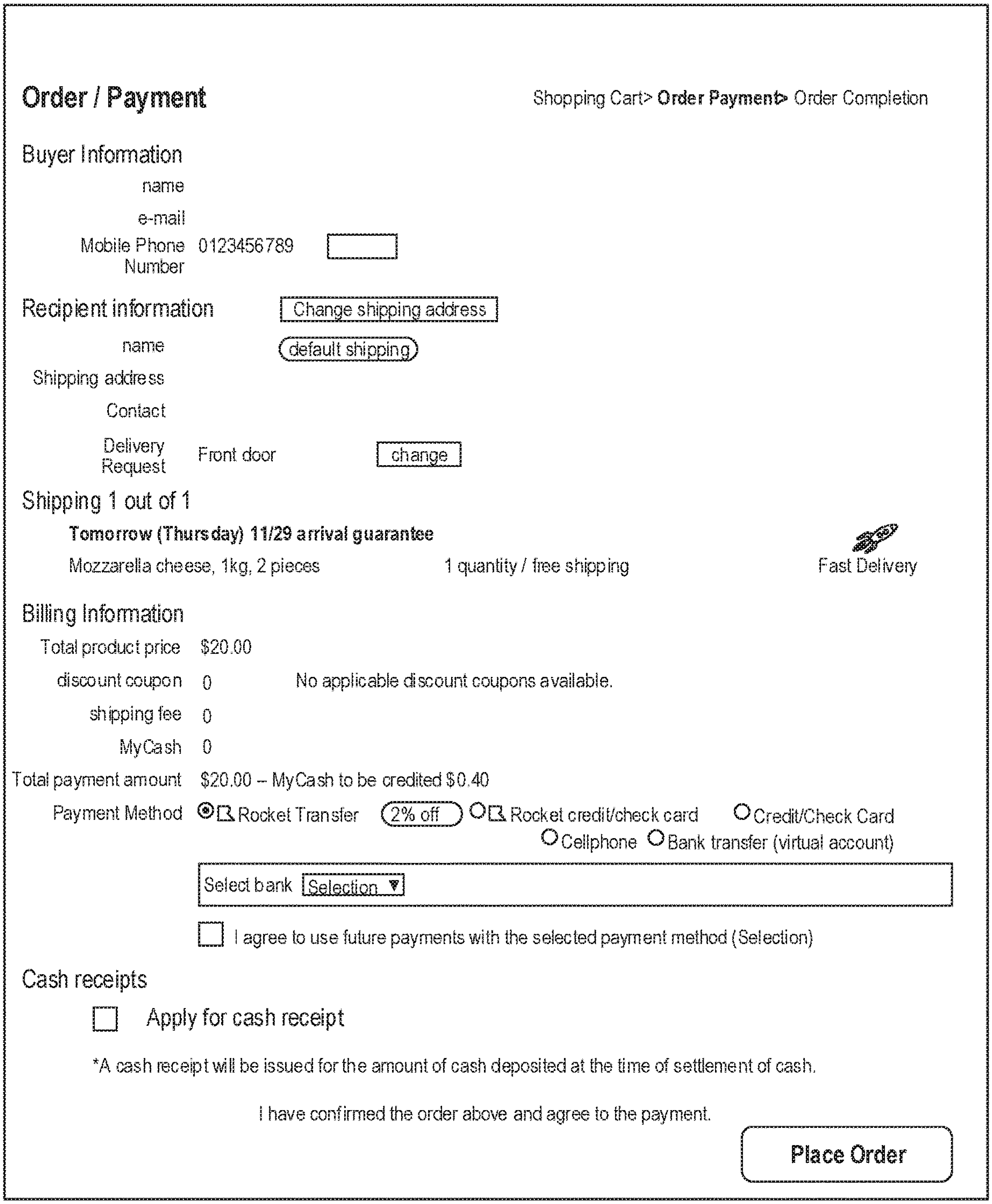

Order / Payment
Shopping Cart> Order Payment> Order Completion
Buyer Information
name
e-mail
Mobile Phone Number 0123456789
Recipient information
Change shipping address
name
default shipping
Shipping address
Contact
Delivery Request Front door
change
Shipping 1 out of 1
Tomorrow (Thursday) 11/29 arrival guarantee
Mozzarella cheese, 1kg, 2 pieces
1 quantity / free shipping
Fast Delivery
Billing Information
Total product price $20.00
discount coupon 0
No applicable discount coupons available.
shipping fee 0
MyCash 0
Total payment amount $20.00 – MyCash to be credited $0.40
Payment Method
Rocket Transfer
2% off
Rocket credit/check card
Credit/Check Card
Cellphone
Bank transfer (virtual account)
Select bank
Selection
I agree to use future payments with the selected payment method (Selection)
Cash receipts
Apply for cash receipt
*A cash receipt will be issued for the amount of cash deposited at the time of settlement of cash.
I have confirmed the order above and agree to the payment.
Place Order

FIG. 1E

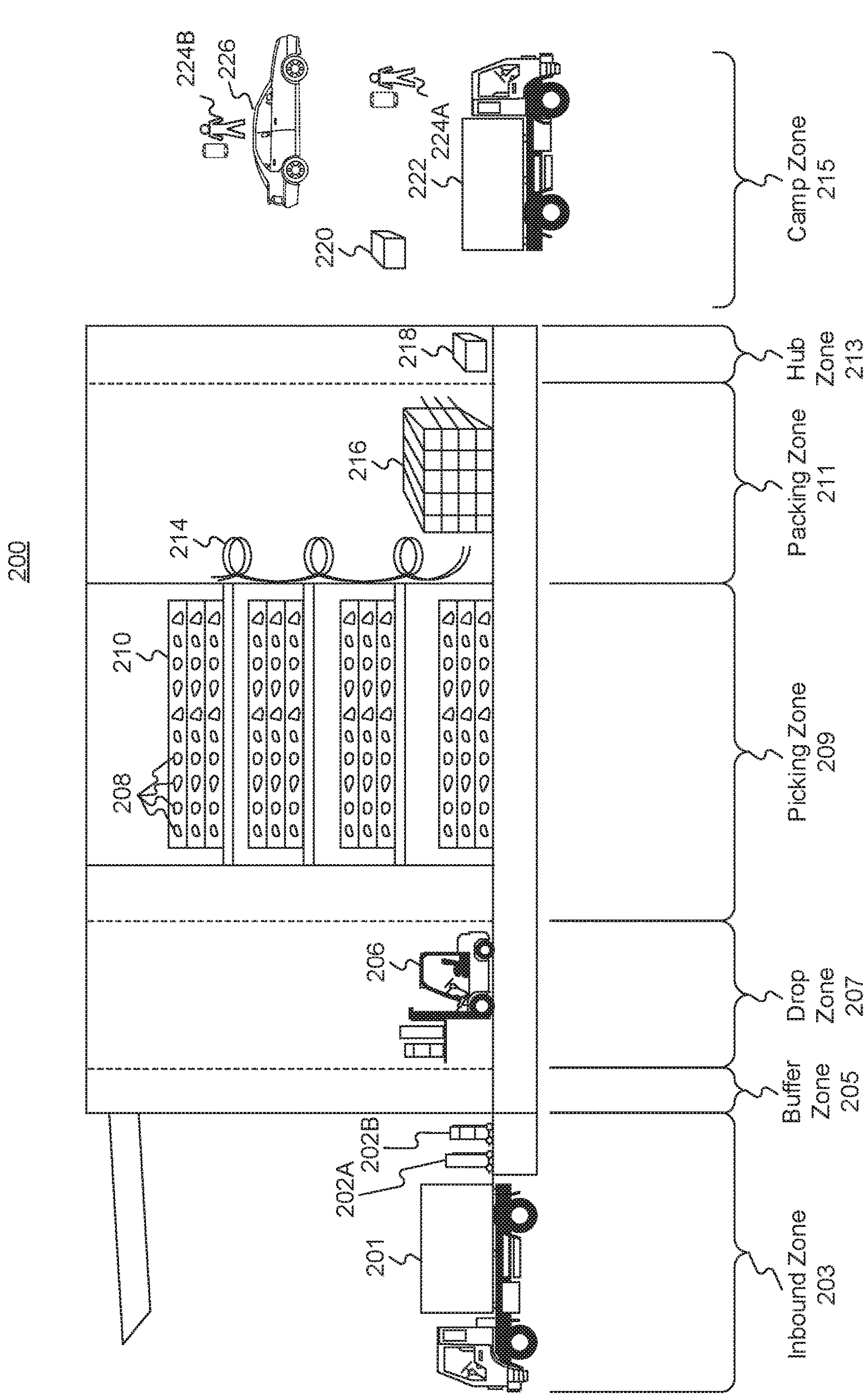

200
201
202A
202B
206
208
210
214
216
218
220
222
224A
224B
226
Inbound Zone
203
Buffer
Zone
205
Drop
Zone
207
Picking Zone
209
Packing Zone
211
Hub
Zone
213
Camp Zone
215

FIG. 2

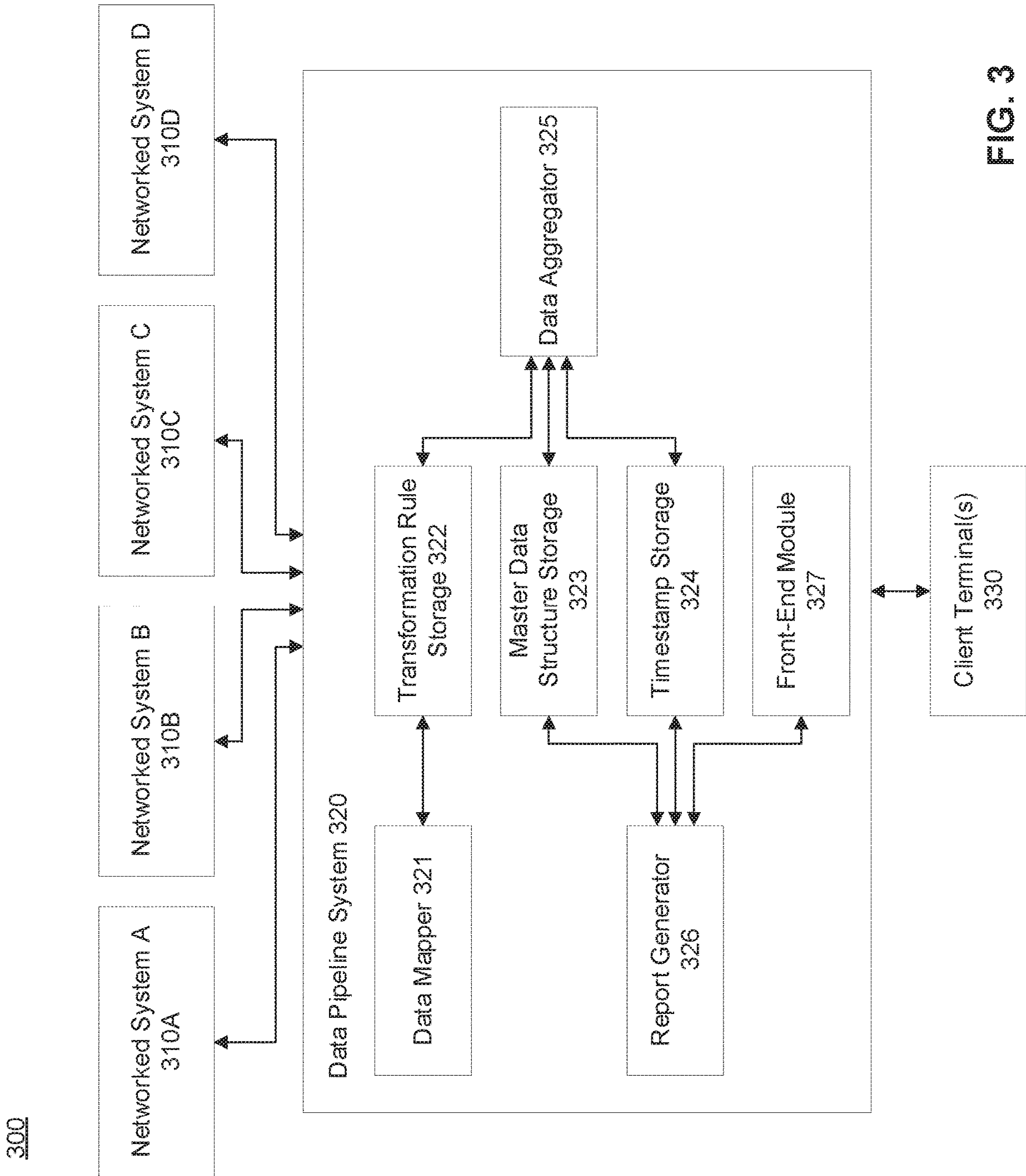

300
Networked System A
310A
Networked System B
310B
Networked System C
310C
Networked System D
310D
Data Pipeline System 320
Data Mapper 321
Transformation Rule
Storage 322
Master Data
Structure Storage
323
Timestamp Storage
324
Data Aggregator 325
Report Generator
326
Front-End Module
327
Client Terminal(s)
330

FIG. 3

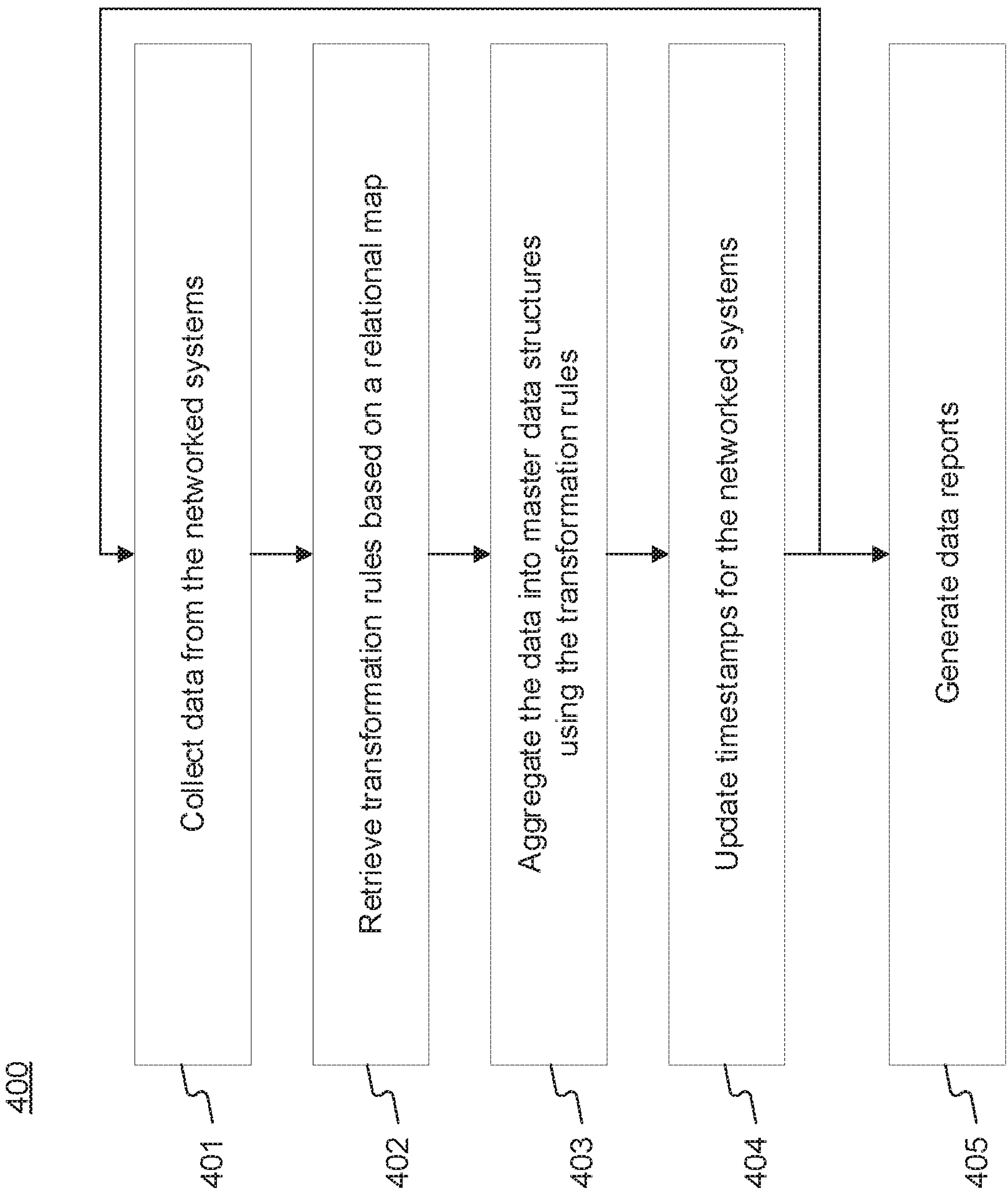

400
Collect data from the networked systems
Retrieve transformation rules based on a relational map
Aggregate the data into master data structures using the transformation rules
Update timestamps for the networked systems
Generate data reports
401
402
403
404
405

FIG. 4

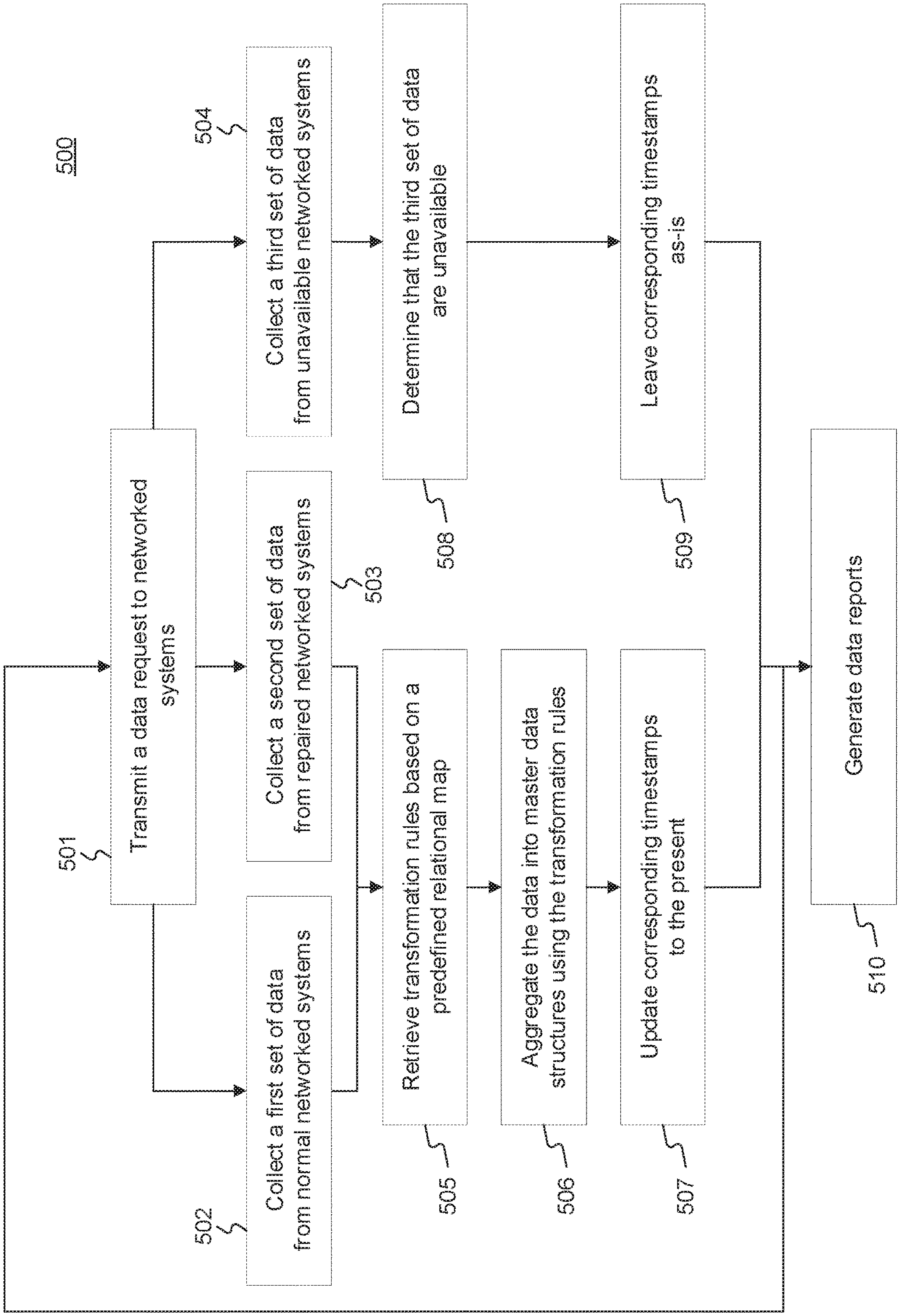

500
501
Transmit a data request to networked systems
502
Collect a first set of data from normal networked systems
503
Collect a second set of data from repaired networked systems
504
Collect a third set of data from unavailable networked systems
505
Retrieve transformation rules based on a predefined relational map
506
Aggregate the data into master data structures using the transformation rules
507
Update corresponding timestamps to the present
508
Determine that the third set of data are unavailable
509
Leave corresponding timestamps as-is
510
Generate data reports

FIG. 5

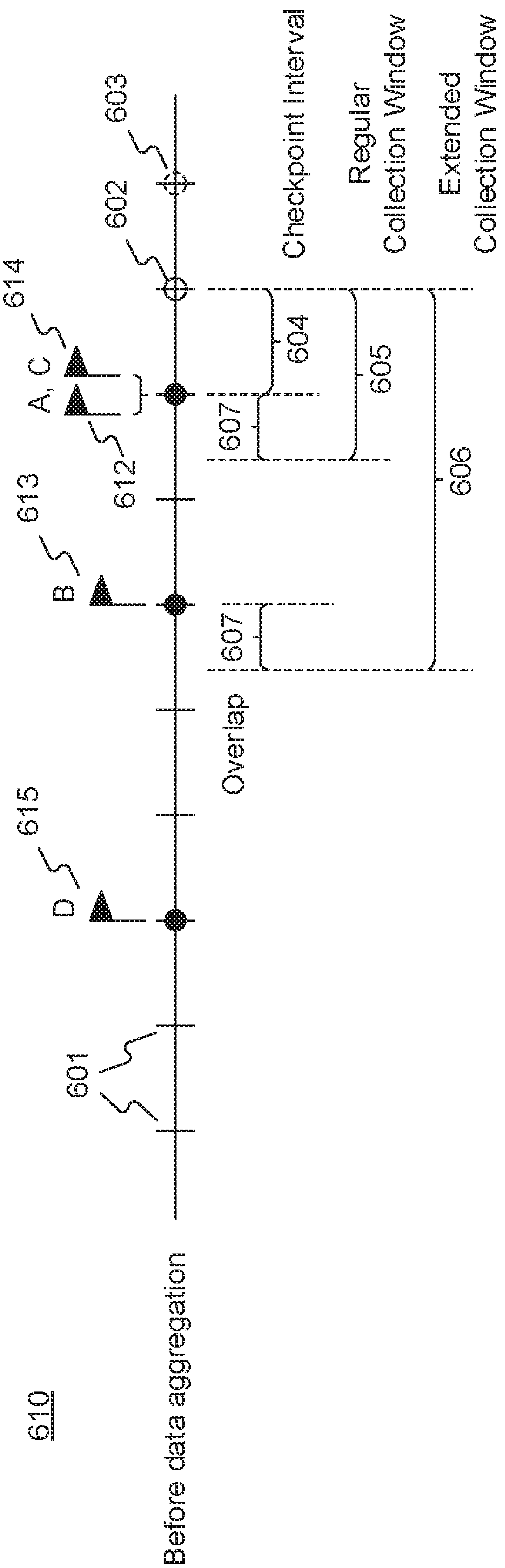

610
Before data aggregation
601
D
615
Overlap
607
B
613
606
612
A, C
614
607
605
604
602
603
Checkpoint Interval
Regular
Collection Window
Extended
Collection Window

FIG. 6A

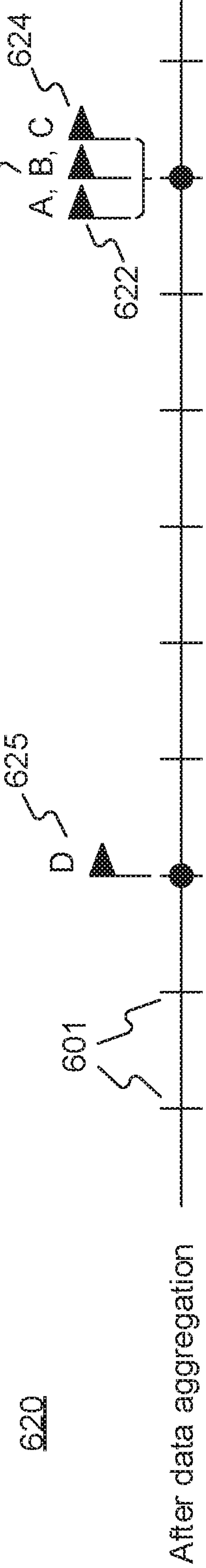

620
After data aggregation
601
D
625
622
A, B, C
623
624
621

FIG. 6B

SYSTEMS AND METHODS FOR DYNAMIC AGGREGATION OF DATA AND MINIMIZATION OF DATA LOSS

TECHNICAL FIELD

The present disclosure generally relates to computerized methods and systems for dynamically aggregating data from multiple networked systems and minimizing data loss from unexpected events such as system outage. In particular, embodiments of the present disclosure relate to inventive and unconventional systems that aggregate data from multiple networked systems that use different data types and formats. The aggregated data are reconciled into a proprietary format that enables near real-time access to arbitrary combinations of data and minimizes data loss.

BACKGROUND

Advancement of information technology has a wide implementation of networked systems where businesses of various sizes utilize multiple computing systems to facilitate their operations. The use can range from simple event logging to database management and analytics. As more operations are computerized and businesses grow in size, the volume of available data is rapidly increasing and frequently overwhelming. Moreover, different networked systems may use different data types and formats, making it difficult for business owners and managers to understand the vast amount of data and make appropriate decisions. Effective and efficient management of such vast amount of data can provide significant competitive advantage.

Another complicating factor arises in collection and storage of such data, where networked systems are susceptible to unexpected problems such as network-wide outages or system level failures. These circumstances are detrimental to the collection and storage of data from the networked systems because network outages can prevent all data from being transferred from one system to another and system level failures can result in data loss until the problems are resolved. Prior art systems have not been able to account for such failures, skipping data aggregation if a networked system is unavailable or being unable to resume aggregation from the last successful aggregation.

Still further, the data collection is also without merit if the data collection and analysis occur over a long period of time. "A long period" is a relative term where even a 10-minute delay in the collection and analysis may be too long in some circumstances while other systems may be okay with collecting data only once per day. As business operations advance to require more rapid responses, however, a real-time or a near real-time data collection and analysis become more important.

Therefore, there is a need for dynamic aggregation of data in near real-time from different networked systems that can collect data of different formats and types, reconciling them to a single format to support sophisticated analysis, while being robust enough to account for unexpected problems and resume collection once the problems are resolved.

SUMMARY

One aspect of the present disclosure is directed to a computer-implemented system for dynamic aggregation of data and minimization of data loss. The system may comprise a memory storing instructions; and at least one processor configured to execute the instructions. The instructions may comprise: aggregating information from a plurality of networked systems by collecting a first set of data at a first time point from the networked systems, the first set of data comprising data associated with a predetermined period of time and comprising one or more central variables that are included in data associated with more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables, each of the central variables and the associated variables comprising a corresponding value; retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables; and aggregating the first set of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables; and generating one or more data reports based on the master data structures.

Yet another aspect of the present disclosure is directed to a computer-implemented method for dynamic aggregation of data and minimization of data loss. The method may comprise steps for aggregating information from a plurality of networked systems by: collecting a first set of data at a first time point from the networked systems, the first set of data comprising data associated with a predetermined period of time and comprising one or more central variables that are included in data associated with more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables, each of the central variables and the associated variables comprising a corresponding value; retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables; and aggregating the first set of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables; and generating one or more data reports based on the master data structures.

Furthermore, another aspect of the present disclosure is directed to a computer-implemented system for dynamic aggregation of data and minimization of data loss. The system may comprise a memory storing instructions; and at least one processor configured to execute the instructions. The instructions may comprise aggregating information from a plurality of networked systems by: transmitting a data request to the networked systems at a predetermined interval; receiving a first set of data at a first time point from a first subset of networked systems, the first subset of networked systems having a first set of corresponding timestamps from an immediately preceding time point, and the first set of data comprising data associated with a predetermined period of time; receiving a second set of data at the first time point from a second subset of networked systems, the second subset of networked systems having a second set of corresponding timestamps from a second time point older than the immediately preceding time point, and the second set of data comprising data associated with a period between the second time point and the first time point; receiving a third set of data at the first time point from a third subset of networked systems, the third subset of networked systems having a third set of corresponding timestamps from the immediately preceding time point, and the third set of data indicating that the third subset of networked systems are not available, wherein the first set of data and the second set of data comprise one or more central variables that are included in data from more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables; retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables; aggregating the first and second sets of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables; and updating the first and second sets of corresponding timestamps based on the first time point; and generating one or more data reports based on the master data structures.

Other systems, methods, and computer-readable media are also discussed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic block diagram illustrating an exemplary embodiment of a network comprising computerized systems for communications enabling shipping, transportation, and logistics operations, consistent with the disclosed embodiments.

FIG. **1**B depicts a sample Search Result Page (SRP) that includes one or more search results satisfying a search request along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. **1**C depicts a sample Single Display Page (SDP) that includes a product and information about the product along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. **1**D depicts a sample Cart page that includes items in a virtual shopping cart along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. **1**E depicts a sample Order page that includes items from the virtual shopping cart along with information regarding purchase and shipping, along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. **2** is a diagrammatic illustration of an exemplary fulfillment center configured to utilize disclosed computerized systems, consistent with the disclosed embodiments.

FIG. **3** depicts a schematic block diagram illustrating an exemplary embodiment of a networked environment comprising computerized systems for aggregating data and minimizing data loss, consistent with the disclosed embodiments.

FIG. **4** depicts a flowchart of an exemplary computerized process for aggregating data from a plurality of networked systems, consistent with the disclosed embodiments.

FIG. **5** depicts a flowchart of an extended exemplary computerized process for aggregating data from a plurality of networked systems with additional steps for minimizing data loss, consistent with the disclosed embodiments.

FIGS. **6**A and **6**B depict exemplary timelines of timestamps for different networked systems before and after data aggregation, consistent with the disclosed embodiments.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several illustrative embodiments are described herein, modifications, adaptations and other implementations are possible. For example, substitutions, additions, or modifications may be made to the components and steps illustrated in the drawings, and the illustrative methods described herein may be modified by substituting, reordering, removing, or adding steps to the disclosed methods. Accordingly, the following detailed description is not limited to the disclosed embodiments and examples. Instead, the proper scope of the invention is defined by the appended claims.

Embodiments of the present disclosure are directed to systems and methods for dynamic aggregation of data and minimization of data loss.

Referring to FIG. **1**A, a schematic block diagram **100** illustrating an exemplary embodiment of a system comprising computerized systems for communications enabling shipping, transportation, and logistics operations is shown. As illustrated in FIG. **1**A, system **100** may include a variety of systems, each of which may be connected to one another via one or more networks. The systems may also be connected to one another via a direct connection, for example, using a cable. The depicted systems include a shipment authority technology (SAT) system **101**, an external front end system **103**, an internal front end system **105**, a transportation system **107**, mobile devices **107**A, **107**B, and **107**C, seller portal **109**, shipment and order tracking (SOT) system **111**, fulfillment optimization (FO) system **113**, fulfillment messaging gateway (FMG) **115**, supply chain management (SCM) system **117**, workforce management system **119**, mobile devices **119**A, **119**B, and **119**C (depicted as being inside of fulfillment center (FC) **200**), 3rd party fulfillment systems **121**A, **121**B, and **121**C, fulfillment center authorization system (FC Auth) **123**, and labor management system (LMS) **125**.

SAT system **101**, in some embodiments, may be implemented as a computer system that monitors order status and delivery status. For example, SAT system **101** may determine whether an order is past its Promised Delivery Date (PDD) and may take appropriate action, including initiating a new order, reshipping the items in the non-delivered order, canceling the non-delivered order, initiating contact with the ordering customer, or the like. SAT system **101** may also monitor other data, including output (such as a number of packages shipped during a particular time period) and input (such as the number of empty cardboard boxes received for use in shipping). SAT system **101** may also act as a gateway between different devices in system **100**, enabling communication (e.g., using store-and-forward or other techniques) between devices such as external front end system **103** and FO system **113**.

External front end system **103**, in some embodiments, may be implemented as a computer system that enables external users to interact with one or more systems in system **100**. For example, in embodiments where system **100** enables the presentation of systems to enable users to place an order for an item, external front end system **103** may be implemented as a web server that receives search requests, presents item pages, and solicits payment information. For example, external front end system **103** may be implemented as a computer or computers running software such as the Apache HTTP Server, Microsoft Internet Information Services (IIS), NGINX, or the like. In other embodiments, external front end system **103** may run custom web server software designed to receive and process requests from external devices (e.g., mobile device **102**A or computer **102**B), acquire information from databases and other data stores based on those requests, and provide responses to the received requests based on acquired information.

In some embodiments, external front end system **103** may include one or more of a web caching system, a database, a search system, or a payment system. In one aspect, external front end system **103** may comprise one or more of these systems, while in another aspect, external front end system **103** may comprise interfaces (e.g., server-to-server, database-to-database, or other network connections) connected to one or more of these systems.

An illustrative set of steps, illustrated by FIGS. **1**B, **1**C, **1**D, and **1**E, will help to describe some operations of external front end system **103**. External front end system **103** may receive information from systems or devices in system **100** for presentation and/or display. For example, external front end system **103** may host or provide one or more web pages, including a Search Result Page (SRP) (e.g., FIG. **1**B), a Single Detail Page (SDP) (e.g., FIG. **1**C), a Cart page (e.g., FIG. **1**D), or an Order page (e.g., FIG. **1**E). A user device (e.g., using mobile device **102**A or computer **102**B) may navigate to external front end system **103** and request a search by entering information into a search box. External front end system **103** may request information from one or more systems in system **100**. For example, external front end system **103** may request information from FO System **113** that satisfies the search request. External front end system **103** may also request and receive (from FO System **113**) a Promised Delivery Date or "PDD" for each product included in the search results. The PDD, in some embodiments, may represent an estimate of when a package containing the product will arrive at the user's desired location or a date by which the product is promised to be delivered at the user's desired location if ordered within a particular period of time, for example, by the end of the day (11:59 PM). (PDD is discussed further below with respect to FO System **113**.)

External front end system **103** may prepare an SRP (e.g., FIG. **1**B) based on the information. The SRP may include information that satisfies the search request. For example, this may include pictures of products that satisfy the search request. The SRP may also include respective prices for each product, or information relating to enhanced delivery options for each product, PDD, weight, size, offers, discounts, or the like. External front end system **103** may send the SRP to the requesting user device (e.g., via a network).

A user device may then select a product from the SRP, e.g., by clicking or tapping a user interface, or using another input device, to select a product represented on the SRP. The user device may formulate a request for information on the selected product and send it to external front end system **103**. In response, external front end system **103** may request information related to the selected product. For example, the information may include additional information beyond that presented for a product on the respective SRP. This could include, for example, shelf life, country of origin, weight, size, number of items in package, handling instructions, or other information about the product. The information could also include recommendations for similar products (based on, for example, big data and/or machine learning analysis of customers who bought this product and at least one other product), answers to frequently asked questions, reviews from customers, manufacturer information, pictures, or the like.

External front end system **103** may prepare an SDP (Single Detail Page) (e.g., FIG. **1**C) based on the received product information. The SDP may also include other interactive elements such as a "Buy Now" button, a "Add to Cart" button, a quantity field, a picture of the item, or the like. The SDP may further include a list of sellers that offer the product. The list may be ordered based on the price each seller offers such that the seller that offers to sell the product at the lowest price may be listed at the top. The list may also be ordered based on the seller ranking such that the highest ranked seller may be listed at the top. The seller ranking may be formulated based on multiple factors, including, for example, the seller's past track record of meeting a promised PDD. External front end system **103** may deliver the SDP to the requesting user device (e.g., via a network).

The requesting user device may receive the SDP which lists the product information. Upon receiving the SDP, the user device may then interact with the SDP. For example, a user of the requesting user device may click or otherwise interact with a "Place in Cart" button on the SDP. This adds the product to a shopping cart associated with the user. The user device may transmit this request to add the product to the shopping cart to external front end system **103**.

External front end system **103** may generate a Cart page (e.g., FIG. **1**D). The Cart page, in some embodiments, lists the products that the user has added to a virtual "shopping cart." A user device may request the Cart page by clicking on or otherwise interacting with an icon on the SRP, SDP, or other pages. The Cart page may, in some embodiments, list all products that the user has added to the shopping cart, as well as information about the products in the cart such as a quantity of each product, a price for each product per item, a price for each product based on an associated quantity, information regarding PDD, a delivery method, a shipping cost, user interface elements for modifying the products in the shopping cart (e.g., deletion or modification of a quantity), options for ordering other product or setting up periodic delivery of products, options for setting up interest payments, user interface elements for proceeding to purchase, or the like. A user at a user device may click on or otherwise interact with a user interface element (e.g., a button that reads "Buy Now") to initiate the purchase of the product in the shopping cart. Upon doing so, the user device may transmit this request to initiate the purchase to external front end system **103**.

External front end system **103** may generate an Order page (e.g., FIG. **1**E) in response to receiving the request to initiate a purchase. The Order page, in some embodiments, re-lists the items from the shopping cart and requests input of payment and shipping information. For example, the Order page may include a section requesting information about the purchaser of the items in the shopping cart (e.g., name, address, e-mail address, phone number), information about the recipient (e.g., name, address, phone number, delivery information), shipping information (e.g., speed/method of delivery and/or pickup), payment information (e.g., credit card, bank transfer, check, stored credit), user interface elements to request a cash receipt (e.g., for tax purposes), or the like. External front end system **103** may send the Order page to the user device.

The user device may enter information on the Order page and click or otherwise interact with a user interface element that sends the information to external front end system **103**. From there, external front end system **103** may send the information to different systems in system **100** to enable the creation and processing of a new order with the products in the shopping cart.

In some embodiments, external front end system **103** may be further configured to enable sellers to transmit and receive information relating to orders.

Internal front end system **105**, in some embodiments, may be implemented as a computer system that enables internal users (e.g., employees of an organization that owns, operates, or leases system **100**) to interact with one or more systems in system **100**. For example, in embodiments where network **101** enables the presentation of systems to enable users to place an order for an item, internal front end system **105** may be implemented as a web server that enables internal users to view diagnostic and statistical information about orders, modify item information, or review statistics relating to orders. For example, internal front end system **105** may be implemented as a computer or computers running software such as the Apache HTTP Server, Microsoft Internet Information Services (IIS), NGINX, or the like. In other embodiments, internal front end system **105** may run custom web server software designed to receive and process requests from systems or devices depicted in system **100** (as well as other devices not depicted), acquire information from databases and other data stores based on those requests, and provide responses to the received requests based on acquired information.

In some embodiments, internal front end system **105** may include one or more of a web caching system, a database, a search system, a payment system, an analytics system, an order monitoring system, or the like. In one aspect, internal front end system **105** may comprise one or more of these systems, while in another aspect, internal front end system **105** may comprise interfaces (e.g., server-to-server, database-to-database, or other network connections) connected to one or more of these systems.

Transportation system **107**, in some embodiments, may be implemented as a computer system that enables communication between systems or devices in system **100** and mobile devices **107**A-**107**C. Transportation system **107**, in some embodiments, may receive information from one or more mobile devices **107**A-**107**C (e.g., mobile phones, smart phones, PDAs, or the like). For example, in some embodiments, mobile devices **107**A-**107**C may comprise devices operated by delivery workers. The delivery workers, who may be permanent, temporary, or shift employees, may utilize mobile devices **107**A-**107**C to effect delivery of packages containing the products ordered by users. For example, to deliver a package, the delivery worker may receive a notification on a mobile device indicating which package to deliver and where to deliver it. Upon arriving at the delivery location, the delivery worker may locate the package (e.g., in the back of a truck or in a crate of packages), scan or otherwise capture data associated with an identifier on the package (e.g., a barcode, an image, a text string, an RFID tag, or the like) using the mobile device, and deliver the package (e.g., by leaving it at a front door, leaving it with a security guard, handing it to the recipient, or the like). In some embodiments, the delivery worker may capture photo(s) of the package and/or may obtain a signature using the mobile device. The mobile device may send information to transportation system **107** including information about the delivery, including, for example, time, date, GPS location, photo(s), an identifier associated with the delivery worker, an identifier associated with the mobile device, or the like. Transportation system **107** may store this information in a database (not pictured) for access by other systems in system **100**. Transportation system **107** may, in some embodiments, use this information to prepare and send tracking data to other systems indicating the location of a particular package.

In some embodiments, certain users may use one kind of mobile device (e.g., permanent workers may use a specialized PDA with custom hardware such as a barcode scanner, stylus, and other devices) while other users may use other kinds of mobile devices (e.g., temporary or shift workers may utilize off-the-shelf mobile phones and/or smartphones).

In some embodiments, transportation system **107** may associate a user with each device. For example, transportation system **107** may store an association between a user (represented by, e.g., a user identifier, an employee identifier, or a phone number) and a mobile device (represented by, e.g., an International Mobile Equipment Identity (IMEI), an International Mobile Subscription Identifier (IMSI), a phone number, a Universal Unique Identifier (UUID), or a Globally Unique Identifier (GUID)). Transportation system **107** may use this association in conjunction with data received on deliveries to analyze data stored in the database in order to determine, among other things, a location of the worker, an efficiency of the worker, or a speed of the worker.

Seller portal **109**, in some embodiments, may be implemented as a computer system that enables sellers or other external entities to electronically communicate with one or more systems in system **100**. For example, a seller may utilize a computer system (not pictured) to upload or provide product information, order information, contact information, or the like, for products that the seller wishes to sell through system **100** using seller portal **109**.

Shipment and order tracking system **111**, in some embodiments, may be implemented as a computer system that receives, stores, and forwards information regarding the location of packages containing products ordered by customers (e.g., by a user using devices **102**A-**102**B). In some embodiments, shipment and order tracking system **111** may request or store information from web servers (not pictured) operated by shipping companies that deliver packages containing products ordered by customers.

In some embodiments, shipment and order tracking system **111** may request and store information from systems depicted in system **100**. For example, shipment and order tracking system **111** may request information from transportation system **107**. As discussed above, transportation system **107** may receive information from one or more mobile devices **107**A-**107**C (e.g., mobile phones, smart phones, PDAs, or the like) that are associated with one or more of a user (e.g., a delivery worker) or a vehicle (e.g., a delivery truck). In some embodiments, shipment and order tracking system **111** may also request information from workforce management system (WMS) **119** to determine the location of individual products inside of a fulfillment center (e.g., fulfillment center **200**). Shipment and order tracking system **111** may request data from one or more of transportation system **107** or WMS **119**, process it, and present it to a device (e.g., user devices **102**A and **102**B) upon request.

Fulfillment optimization (FO) system **113**, in some embodiments, may be implemented as a computer system that stores information for customer orders from other systems (e.g., external front end system **103** and/or shipment and order tracking system **111**). FO system **113** may also store information describing where particular items are held or stored. For example, certain items may be stored only in one fulfillment center, while certain other items may be stored in multiple fulfillment centers. In still other embodiments, certain fulfillment centers may be designed to store only a particular set of items (e.g., fresh produce or frozen products). FO system **113** stores this information as well as associated information (e.g., quantity, size, date of receipt, expiration date, etc.).

FO system **113** may also calculate a corresponding PDD (promised delivery date) for each product. The PDD, in some embodiments, may be based on one or more factors.

For example, FO system **113** may calculate a PDD for a product based on a past demand for a product (e.g., how many times that product was ordered during a period of time), an expected demand for a product (e.g., how many customers are forecast to order the product during an upcoming period of time), a network-wide past demand indicating how many products were ordered during a period of time, a network-wide expected demand indicating how many products are expected to be ordered during an upcoming period of time, one or more counts of the product stored in each fulfillment center **200**, which fulfillment center stores each product, expected or current orders for that product, or the like.

In some embodiments, FO system **113** may determine a PDD for each product on a periodic basis (e.g., hourly) and store it in a database for retrieval or sending to other systems (e.g., external front end system **103**, SAT system **101**, shipment and order tracking system **111**). In other embodiments, FO system **113** may receive electronic requests from one or more systems (e.g., external front end system **103**, SAT system **101**, shipment and order tracking system **111**) and calculate the PDD on demand.

Fulfilment messaging gateway (FMG) **115**, in some embodiments, may be implemented as a computer system that receives a request or response in one format or protocol from one or more systems in system **100**, such as FO system **113**, converts it to another format or protocol, and forward it in the converted format or protocol to other systems, such as WMS **119** or 3[rd] party fulfillment systems **121**A, **121**B, or **121**C, and vice versa.

Supply chain management (SCM) system **117**, in some embodiments, may be implemented as a computer system that performs forecasting functions. For example, SCM system **117** may forecast a level of demand for a particular product based on, for example, based on a past demand for products, an expected demand for a product, a network-wide past demand, a network-wide expected demand, a count products stored in each fulfillment center **200**, expected or current orders for each product, or the like. In response to this forecasted level and the amount of each product across all fulfillment centers, SCM system **117** may generate one or more purchase orders to purchase and stock a sufficient quantity to satisfy the forecasted demand for a particular product.

Workforce management system (WMS) **119**, in some embodiments, may be implemented as a computer system that monitors workflow. For example, WMS **119** may receive event data from individual devices (e.g., devices **107**A-**107**C or **119**A-**119**C) indicating discrete events. For example, WMS **119** may receive event data indicating the use of one of these devices to scan a package. As discussed below with respect to fulfillment center **200** and FIG. **2**, during the fulfillment process, a package identifier (e.g., a barcode or RFID tag data) may be scanned or read by machines at particular stages (e.g., automated or handheld barcode scanners, RFID readers, high-speed cameras, devices such as tablet **119**A, mobile device/PDA **1198**, computer **119**C, or the like). WMS **119** may store each event indicating a scan or a read of a package identifier in a corresponding database (not pictured) along with the package identifier, a time, date, location, user identifier, or other information, and may provide this information to other systems (e.g., shipment and order tracking system **111**).

WMS **119**, in some embodiments, may store information associating one or more devices (e.g., devices **107**A-**107**C or **119**A-**119**C) with one or more users associated with system **100**. For example, in some situations, a user (such as a part- or full-time employee) may be associated with a mobile device in that the user owns the mobile device (e.g., the mobile device is a smartphone). In other situations, a user may be associated with a mobile device in that the user is temporarily in custody of the mobile device (e.g., the user checked the mobile device out at the start of the day, will use it during the day, and will return it at the end of the day).

WMS **119**, in some embodiments, may maintain a work log for each user associated with system **100**. For example, WMS **119** may store information associated with each employee, including any assigned processes (e.g., unloading trucks, picking items from a pick zone, rebin wall work, packing items), a user identifier, a location (e.g., a floor or zone in a fulfillment center **200**), a number of units moved through the system by the employee (e.g., number of items picked, number of items packed), an identifier associated with a device (e.g., devices **119**A-**119**C), or the like. In some embodiments, WMS **119** may receive check-in and check-out information from a timekeeping system, such as a timekeeping system operated on a device **119**A-**119**C.

3[rd] party fulfillment (3PL) systems **121**A-**121**C, in some embodiments, represent computer systems associated with third-party providers of logistics and products. For example, while some products are stored in fulfillment center **200** (as discussed below with respect to FIG. **2**), other products may be stored off-site, may be produced on demand, or may be otherwise unavailable for storage in fulfillment center **200**. 3PL systems **121**A-**121**C may be configured to receive orders from FO system **113** (e.g., through FMG **115**) and may provide products and/or services (e.g., delivery or installation) to customers directly. In some embodiments, one or more of 3PL systems **121**A-**121**C may be part of system **100**, while in other embodiments, one or more of 3PL systems **121**A-**121**C may be outside of system **100** (e.g., owned or operated by a third-party provider).

Fulfillment Center Auth system (FC Auth) **123**, in some embodiments, may be implemented as a computer system with a variety of functions. For example, in some embodiments, FC Auth **123** may act as a single-sign on (SSO) service for one or more other systems in system **100**. For example, FC Auth **123** may enable a user to log in via internal front end system **105**, determine that the user has similar privileges to access resources at shipment and order tracking system **111**, and enable the user to access those privileges without requiring a second log in process. FC Auth **123**, in other embodiments, may enable users (e.g., employees) to associate themselves with a particular task. For example, some employees may not have an electronic device (such as devices **119**A-**119**C) and may instead move from task to task, and zone to zone, within a fulfillment center **200**, during the course of a day. FC Auth **123** may be configured to enable those employees to indicate what task they are performing and what zone they are in at different times of day.

Labor management system (LMS) **125**, in some embodiments, may be implemented as a computer system that stores attendance and overtime information for employees (including full-time and part-time employees). For example, LMS **125** may receive information from FC Auth **123**, WMA **119**, devices **119**A-**119**C, transportation system **107**, and/or devices **107**A-**107**C.

The particular configuration depicted in FIG. **1**A is an example only. For example, while FIG. **1**A depicts FC Auth system **123** connected to FO system **113**, not all embodiments require this particular configuration. Indeed, in some embodiments, the systems in system **100** may be connected to one another through one or more public or private networks, including the Internet, an Intranet, a WAN (Wide-Area Network), a MAN (Metropolitan-Area Network), a wireless network compliant with the IEEE 802.11a/b/g/n Standards, a leased line, or the like. In some embodiments, one or more of the systems in system **100** may be implemented as one or more virtual servers implemented at a data center, server farm, or the like.

FIG. **2** depicts a fulfillment center **200**. Fulfillment center **200** is an example of a physical location that stores items for shipping to customers when ordered. Fulfillment center (FC) **200** may be divided into multiple zones, each of which are depicted in FIG. **2**. These "zones," in some embodiments, may be thought of as virtual divisions between different stages of a process of receiving items, storing the items, retrieving the items, and shipping the items. So while the "zones" are depicted in FIG. **2**, other divisions of zones are possible, and the zones in FIG. **2** may be omitted, duplicated, or modified in some embodiments.

Inbound zone **203** represents an area of FC **200** where items are received from sellers who wish to sell products using system **100** from FIG. **1**A. For example, a seller may deliver items **202**A and **202**B using truck **201**. Item **202**A may represent a single item large enough to occupy its own shipping pallet, while item **202**B may represent a set of items that are stacked together on the same pallet to save space.

A worker will receive the items in inbound zone **203** and may optionally check the items for damage and correctness using a computer system (not pictured). For example, the worker may use a computer system to compare the quantity of items **202**A and **202**B to an ordered quantity of items. If the quantity does not match, that worker may refuse one or more of items **202**A or **2028**. If the quantity does match, the worker may move those items (using, e.g., a dolly, a handtruck, a forklift, or manually) to buffer zone **205**. Buffer zone **205** may be a temporary storage area for items that are not currently needed in the picking zone, for example, because there is a high enough quantity of that item in the picking zone to satisfy forecasted demand. In some embodiments, forklifts **206** operate to move items around buffer zone **205** and between inbound zone **203** and drop zone **207**. If there is a need for items **202**A or **202**B in the picking zone (e.g., because of forecasted demand), a forklift may move items **202**A or **202**B to drop zone **207**.

Drop zone **207** may be an area of FC **200** that stores items before they are moved to picking zone **209**. A worker assigned to the picking task (a "picker") may approach items **202**A and **202**B in the picking zone, scan a barcode for the picking zone, and scan barcodes associated with items **202**A and **202**B using a mobile device (e.g., device **119**B). The picker may then take the item to picking zone **209** (e.g., by placing it on a cart or carrying it).

Picking zone **209** may be an area of FC **200** where items **208** are stored on storage units **210**. In some embodiments, storage units **210** may comprise one or more of physical shelving, bookshelves, boxes, totes, refrigerators, freezers, cold stores, or the like. In some embodiments, picking zone **209** may be organized into multiple floors. In some embodiments, workers or machines may move items into picking zone **209** in multiple ways, including, for example, a forklift, an elevator, a conveyor belt, a cart, a handtruck, a dolly, an automated robot or device, or manually. For example, a picker may place items **202**A and **202**B on a handtruck or cart in drop zone **207** and walk items **202**A and **202**B to picking zone **209**.

A picker may receive an instruction to place (or "stow") the items in particular spots in picking zone **209**, such as a particular space on a storage unit **210**. For example, a picker may scan item **202**A using a mobile device (e.g., device **119**B). The device may indicate where the picker should stow item **202**A, for example, using a system that indicate an aisle, shelf, and location. The device may then prompt the picker to scan a barcode at that location before stowing item **202**A in that location. The device may send (e.g., via a wireless network) data to a computer system such as WMS **119** in FIG. **1**A indicating that item **202**A has been stowed at the location by the user using device **1198**.

Once a user places an order, a picker may receive an instruction on device **1198** to retrieve one or more items **208** from storage unit **210**. The picker may retrieve item **208**, scan a barcode on item **208**, and place it on transport mechanism **214**. While transport mechanism **214** is represented as a slide, in some embodiments, transport mechanism may be implemented as one or more of a conveyor belt, an elevator, a cart, a forklift, a handtruck, a dolly, a cart, or the like. Item **208** may then arrive at packing zone **211**.

Packing zone **211** may be an area of FC **200** where items are received from picking zone **209** and packed into boxes or bags for eventual shipping to customers. In packing zone **211**, a worker assigned to receiving items (a "rebin worker") will receive item **208** from picking zone **209** and determine what order it corresponds to. For example, the rebin worker may use a device, such as computer **119**C, to scan a barcode on item **208**. Computer **119**C may indicate visually which order item **208** is associated with. This may include, for example, a space or "cell" on a wall **216** that corresponds to an order. Once the order is complete (e.g., because the cell contains all items for the order), the rebin worker may indicate to a packing worker (or "packer") that the order is complete. The packer may retrieve the items from the cell and place them in a box or bag for shipping. The packer may then send the box or bag to a hub zone **213**, e.g., via forklift, cart, dolly, handtruck, conveyor belt, manually, or otherwise.

Hub zone **213** may be an area of FC **200** that receives all boxes or bags ("packages") from packing zone **211**. Workers and/or machines in hub zone **213** may retrieve package **218** and determine which portion of a delivery area each package is intended to go to, and route the package to an appropriate camp zone **215**. For example, if the delivery area has two smaller sub-areas, packages will go to one of two camp zones **215**. In some embodiments, a worker or machine may scan a package (e.g., using one of devices **119**A-**119**C) to determine its eventual destination. Routing the package to camp zone **215** may comprise, for example, determining a portion of a geographical area that the package is destined for (e.g., based on a postal code) and determining a camp zone **215** associated with the portion of the geographical area.

Camp zone **215**, in some embodiments, may comprise one or more buildings, one or more physical spaces, or one or more areas, where packages are received from hub zone **213** for sorting into routes and/or sub-routes. In some embodiments, camp zone **215** is physically separate from FC **200** while in other embodiments camp zone **215** may form a part of FC **200**.

Workers and/or machines in camp zone **215** may determine which route and/or sub-route a package **220** should be associated with, for example, based on a comparison of the destination to an existing route and/or sub-route, a calculation of workload for each route and/or sub-route, the time of day, a shipping method, the cost to ship the package **220**, a PDD associated with the items in package **220**, or the like. In some embodiments, a worker or machine may scan a package (e.g., using one of devices **119**A-**119**C) to determine its eventual destination. Once package **220** is assigned to a particular route and/or sub-route, a worker and/or machine may move package **220** to be shipped. In exemplary FIG. **2**, camp zone **215** includes a truck **222**, a car **226**, and delivery workers **224**A and **224**B. In some embodiments, truck **222** may be driven by delivery worker **224**A, where delivery worker **224**A is a full-time employee that delivers packages for FC **200** and truck **222** is owned, leased, or operated by the same company that owns, leases, or operates FC **200**. In some embodiments, car **226** may be driven by delivery worker **224**B, where delivery worker **224**B is a "flex" or occasional worker that is delivering on an as-needed basis (e.g., seasonally). Car **226** may be owned, leased, or operated by delivery worker **224**B.

FIG. **3** depicts a schematic block diagram illustrating an exemplary embodiment of a networked environment **300** comprising computerized systems for aggregating data and minimizing data loss. Environment **300** may include a variety of systems, each of which may be connected to one another via one or more networks. The systems may also be connected to one another via a direct connection, for example, using a cable. The depicted systems include networked systems A-D **310**A-D, a data pipeline system (DPS) **320**, and one or more client terminals **320**.

Networked systems **310**A-D, in some embodiments, may be implemented as one or more computer systems that collect, accrue, and/or generate various data as part of their respective operations. For example, networked systems **310**A-D may be similar in design, function, or operation to FO system **113**, WMS **119**, FC Auth **123**, and LMS **125** of FIG. **1**A, respectively. Alternatively, one or more of the networked systems **310**A-D may be implemented as one or more databases or memories configured to store data collected, accrued, and/or generated by the respective computer systems. In some embodiments, such databases or memories may include cloud-based databases or on-premises databases. Also in some embodiments, such databases or memories may comprise one or more hard disk drives, one or more solid state drives, or one or more non-transitory memories. While only four networked systems **310**A-D are depicted in FIG. **3**, the number is only exemplary and networked systems may include any number of systems.

DPS **320**, in some embodiments, may be implemented as a computer system configured to dynamically aggregate data from networked systems **310**A-D that allows a user to analyze the data in multiple perspectives (e.g., performance over time, performance by zone, etc.). DPS **320** may also be configured to minimize data loss in the event of an unexpected system failure or a network failure by remembering exactly when it last aggregated data from a networked system in the event of a failure and resuming the aggregation from the particular networked system once the failure is resolved.

In some embodiments, DPS **320** comprises a data mapper **321**, a transformation rule storage **322**, a master data structure (MDS) storage **323**, a timestamp storage **324**, a data aggregator **325**, and a report generator **326**. In addition, DPS **320** may also comprise a front-end module **327** that receives data analysis queries from client terminals **330** and transmits outputs from report generator **326** to client terminals **330**.

In some embodiments, DPS **320** may comprise one or more processors, one or more memories, and one or more input/output (I/O) devices. DPS **320** may take the form of a server, general-purpose computer, a mainframe computer, a special-purpose computing device such as a graphical processing unit (GPU), laptop, or any combination of these computing devices. In these embodiments, components of DPS **320** (i.e., data mapper **321**, transformation rule storage **322**, MDS storage **323**, timestamp storage **324**, data aggregator **325**, report generator **326**, and front-end module **327**) may be implemented as one or more functional units performed by one or more processors based on instructions stored in the one or more memories. DPS **320** may be a standalone system, or it may be part of a subsystem, which may be part of a larger system.

Alternatively, components of DPS **320** may be implemented as one or more computer systems communicating with each other via a network. In this embodiment, each of the one or more computer systems may comprise one or more processors, one or more memories (i.e., non-transitory computer-readable media), and one or more input/output (I/O) devices. In some embodiments, each of the one or more computer systems may take the form of a server, general-purpose computer, a mainframe computer, a special-purpose computing device such as a GPU, laptop, or any combination of these computing devices.

Data mapper **321**, in some embodiments, may include one or more computing devices configured to determine a relational map between one or more variables included in the data retrieved from networked systems **310**A-D. The relational map may define how different variables included in the data from each networked systems **310**A-D are related to each other. In some embodiments, data mapper **321** may define the relational map based on how one or more central variables that are associated with data from more than one of the networked systems are related to one or more associated variables that describe certain aspects of the central variables.

For example, when networked systems **310**A-D includes WMS **119** and LMS **125** of FIG. **1**A, data from the two systems may both contain worker identifier, where data from WMS **119** may describe a series of event data associated with the worker identifier (e.g., worker X scanned product identifier A for order identifier P at time T). Similarly data from LMS **125** may describe attendance and overtime information associated with the worker identifier (e.g., worker X worked from time T1 to time T2 on date D). Data mapper **321** may identify that the worker identifier is a central variable that can consolidate data from WMS **119** and LMS **125** and consolidate the data to describe the worker based on other associated variables (e.g., time T1, T2, T, order identifier P, etc.). Additionally or alternatively, data mapper **321** may identify order identifier as a central variable and consolidate data using other variables to describe the corresponding order (e.g., order identifier P containing product identifier A was scanned by worker identifier X at time T).

As described above, data mapper **321** may consolidate knowledge of the variables as they pertain to a real-world operation and determine a relational map among all variables included in the data from the networked systems **310**A-D. In some embodiments, data mapper **321** may consider data profiles specified by each of the networked systems **310**A-D, which may comprise information such as metadata, definitions of the variables, a data element synonym registry, and the like. The data element synonym registry may be a list of synonyms that may be used to describe a particular variable, which can be used to identify related or identical variables when different networked systems use different terms to describe similar variables.

In some embodiments, data mapper **321** may use the relational map to generate a set of transformation rules that dictate how data from network systems **310**A-D should be organized. In other words, transformation rules may dictate how each variable included in the data from network systems **310**A-D should map to different data fields of one or more MDSes described below. In some embodiments, data mapper **321** may transmit and store the transformation rules in transformation rule storage **322**.

Data aggregator **325**, in some embodiments, may include one or more computing devices configured to retrieve data from one or more networked systems **310**A-D. Data aggregator **325** may than aggregate the retrieved data into one or more MDSes based on transformation rules retrieved from transformation rule storage **322**. Specifically, data aggregator **325** may receive a data from a particular networked system (e.g., **310**A), identify variables therein, retrieve corresponding transformation rules from transformation rule storage **322**, and assign values corresponding to each variable to one or more data fields in one or more MDSes based on the transformation rules. In some embodiments, data aggregator **325** may also update timestamps stored in timestamp storage **324** that correspond to each networked system.

Transformation rule storage **322**, MDS storage **323**, and timestamp storage **324**, in some embodiments, may include one or more databases or memories configured to store corresponding types of data. The three storage units (i.e., transformation rule storage **322**, MDS storage **323**, and timestamp storage **324**), may also be implemented together as a single collection of storage devices, each occupying a portion of the single collection of storage devices. The three storage units may each include, or may collectively include, cloud-based databases or on-premises databases. In some embodiments, the three storage units may each include, or may collectively include, one or more hard disk drives, one or more solid state drives, or one or more non-transitory memories.

Report generator **326**, in some embodiments, may include one or more computing devices configured to generate reports based on data analysis queries received from client terminals **330** via front-end module **327**. The reports can range from simple ones that output last known aggregation time points for the networked systems **310**A-D based on the timestamps stored in timestamp storage **324** to complex ones that require calculation of performance history over time by a particular worker or by a particular facility. In some embodiments, aggregation of data into MDSes may enable report generator **326** to analyze the data in multiple dimensions such as over time, by workers, by zones, by order, and the like. Furthermore, report generator **326** may enable high-level analyses of performance metrics such as number of orders processed per hour, number of idle workers, and number of orders completed on time; and detailed analyses such as average number of units processed per hour for top 10% of workers.

Front-end module **327**, in some embodiments, may be implemented as a computer system that enables external users to interact with one or more components of DPS **320**. For example, in embodiments where DPS **320** enables users to submit a data analysis query, front-end module **327** may be implemented as a web server that receives such queries and presents outcome of the analysis as discussed above. In some embodiments, front-end module **327** may be implemented as a computer or computers running software such as the Apache HTTP Server, Microsoft Internet Information Services (IIS), NGINX, or the like. In other embodiments, front-end module **327** may run a custom web server software designed to receive and process queries from client terminals **330**, instruct other systems to acquire information from databases, run analysis, and provide responses to the received queries based on the acquired information.

Client terminals **330**, in some embodiments, may include one or more computing devices configured to enable users (e.g., business owners or facility operators) to access DPS **320** via front-end module **327**. Client terminals **330** may include any combination of computing devices such as personal computers, mobile phones, smartphones, PDAs, or the like. In some embodiments, users may use client terminals **330** to access a web interface provided by front-end module **327** and submit a query for data analysis. And once the data analysis is complete, users may use client terminals **330** to receive outcomes via the web interface provided by front-end module **327**.

FIG. **4** depicts a flowchart of an exemplary computerized process **400** for aggregating data from a plurality of networked systems. In some embodiments, process **400** may be performed by data aggregator **325** using information from other components of DPS **320** as described above.

FIG. **5** depicts a flowchart of an extended exemplary computerized process **500** for aggregating data from a plurality of networked systems with additional steps for minimizing data loss. In some embodiments, extended process **500** may also be performed by data aggregator **325**, similar to process **400**, using information from other components of DPS **320** as described above.

FIGS. **6**A and **6**B depict exemplary timelines **610** and **620** of timestamps for different networked systems before and after data aggregation. Following descriptions of process **400** and extended process **500** will make reference to FIGS. **6**A and **6**B for clarity.

Referring back to FIG. **4**, data aggregator **325** may repeat steps **401**-**404** at predetermined intervals (i.e., checkpoint interval **604** of FIG. **6**A). At step **401**, data aggregator **325** may begin one cycle of steps **401**-**404** by collecting a set of data from networked systems **310**A-D. This collection of data may occur, for example, at a current time point **602**. Tick marks **601** on timelines **610** and **620** mark different time points (i.e., checkpoints) over time. In some embodiments, data aggregator **325** may retrieve data from each network system (e.g., **310**A) that accumulated over a predetermined period of time called regular collection window **605**, which may be equal to checkpoint interval **604** or longer by a predetermined overlap **607**. In some embodiments, regular collection window **605** may be equal to or longer than twice checkpoint interval **604**.

In some embodiments, checkpoint interval **604** may be user selectable and/or may range anywhere from mere seconds or a fraction of a second to hours or days. A smaller checkpoint interval **604** may allow a more rapid repetition of steps **401**-**404**, which would result in a more frequent data aggregation, allowing report generator **326** to provide more up-to-date data analysis reports. In some embodiments, checkpoint interval **604** may be sufficiently small to provide near real-time or real-time reports.

At step **402**, data aggregator **325** may retrieve data transformation rules from transformation rule storage **322** based on a relational map among central variables and associated variables included in the data from the networked systems **310**A-D. This may involve, in some embodiments, generating, by data aggregator **325**, a list of variables included in the data and querying transformation rule storage **322** to retrieve transformation rules associated with any of the variables.

At step **403**, data aggregator **325** may aggregate the data into one or more master data structures (MDSes) corresponding to the central variables based on the retrieved transformation rules. In some embodiments, each of the MDSes may comprise data fields that correspond to one of the central variables and a subset of the associated variables. For example, an MDS may comprise data fields corresponding to an order identifier, a received date, a PDD, a status identifier, and the like. In other embodiments, each of the MDSes may contain a central data field that corresponds to one of the central variables and contain additional data fields that correspond to any of the central or associated variables. For example, an MDS may comprise a central data field for an order identifier and a plurality of data fields for a received date, a PDD, a status identifier, a worker identifier, and the like.

In this way, data aggregator **325** may, for each data retrieved from networked systems **310**A-D, assign values of variables stored therein to one or more corresponding data fields in one or more MDSes. For example, data aggregator **325** may assign a value for an order identifier included in data from FO system **113** to a central data field in one MDS and a data field in another MDS that use worker identifier as the central variable.

In some embodiments, aggregating the data into MDSes may comprise sorting the data from networked systems **310**A-D based on time from oldest to latest and iterating through the sorted data chronologically to replace existing values in data fields of the MDSes with the values from the data. In some instances where a data field is empty, data aggregator **325** may simply assign the value from the data as a new value for the data field.

At step **404**, data aggregator **325** updates timestamps (e.g., timestamp A **612** and timestamp C **614** for networked systems A and C **310**A and **310**C) for networked systems **310**A-D. Timestamp storage **324** may store and keep track of timestamps for each networked system **310**A-D. Under normal operation where there has been no unexpected failure, all timestamps may be set to a time point immediately preceding current time point **602** during a previous data aggregation, like timestamps A **612** and C **614** in FIG. **6**A. After a successful data aggregation, data aggregator **325** may update corresponding timestamps to the current time point **602**, like an updated timestamp A **622** and an updated timestamp C **624** in FIG. **6**B.

Once data aggregation is complete, data aggregator **325** may wait until the next time point **603**, a checkpoint interval in the future from current time point **602**, and repeat steps **401**-**404**. Additionally or alternatively, report generator **326** may, at step **405**, generate data reports in response to data analysis queries submitted by a user via client terminal(s) **330** as described above.

Referring to FIG. **5**, extended process **500** depicts more detail to process **400** that allows DPS **320** to keep track of data aggregation with respect to each networked system and minimize data loss. Given a number of networked systems **310**A-D, the systems are always at risk of unexpected failures such as a network outage or a system-level failure. As such, networked systems **310**A-D may be divided into three categories at any given moment: (1) those that completed data aggregation at the immediately preceding checkpoint (normal networked systems), (2) those that had been unavailable for any number of reasons but are currently available for aggregation (i.e., repaired networked systems), and (3) those that are currently unavailable (unavailable networked systems).

At the beginning of a data aggregation cycle (e.g., steps **401**-**404** of FIG. **4**), data aggregator **325** may, at step **501**, transmit a data request to networked systems **310**A-D. In response, data aggregator **325** may receive and collect three sets of data from the three categories of networked systems **310**A-D. Specifically, data aggregator **325** may receive, at step **502**, a first set of data from normal networked systems (e.g., **310**A and **310**C); at step **503**, a second set of data from repaired networked systems (e.g., **310**B); and at step **504**, a third set of data from unavailable networked systems (e.g., **310**D). In some embodiments, unavailable networked systems (e.g., **310**D) may return nothing or a timeout exception. And in some embodiments, data aggregator **325** may identify different categories of networked systems **310**A-D based on the received sets of data as described above and/or based on respective timestamps stored in timestamp storage **324**. For example, the timestamps corresponding to normal networked systems (e.g., **310**A and **310**C) may be set at checkpoint A **612** and checkpoint C **614**, respectively, immediately preceding current time point **602**, and the timestamps corresponding to unavailable or repaired networked systems (e.g., **310**D and **310**B) may be set at any of the previous checkpoints such as checkpoint D **615** and checkpoint B **613**, respectively, because data aggregator **325** may have been unable to update them in a previous cycle, or it may have omitted them to keep track of each networked system. To be clear, data aggregator **325** may differentiate between unavailable and repaired networked systems based on the collected data at step **508**.

For normal and repaired networked systems (e.g., **310**A, **310**C, and **310**B), data aggregator **325** aggregates data in a manner described above with respect to FIG. **4**. However, one of differences between the two categories of networked systems is that data from normal networked systems comprise those that accrued during regular collection window **605** as described above, while data from repaired networked systems comprise those that accrued during an extended collection window **606**. Extended collection window may span, at minimum, the period of time from a corresponding timestamp of the repaired networked system (e.g., timestamp **613**) to the current time point **602**. In some embodiments, extended collection window may also comprise an amount of time equal to predetermined overlap **607**.

After aggregating data from both categories of networked systems, data aggregator may, at step **507**, update corresponding timestamps to current time point **602**. For example, data aggregator **325** may update timestamp A **612** and timestamp C **614** corresponding to normal networked systems **310**A and **310**C to updated timestamp A **622** and updated timestamp C **624**, respectively; and update timestamp B **613** corresponding to repaired networked system **310**B to updated timestamp B **623**.

On the other hand, timestamp (e.g., timestamp D **615**) corresponding to unavailable networked systems (e.g., **310**D) may be stuck at some time point in the past. And data aggregator **325** may also leave the corresponding timestamps as-is in the past at step **509**, so that data aggregator **325** may resume from the last successful data aggregation for the particular networked system when the networked system is repaired. At some point in the future when networked system **310**D is repaired and becomes available again, data aggregator **325** may aggregate the data from a time point preceding timepoint D **615** by predetermined overlap **607** to the then current time point.

Once data aggregation is complete for all three categories of networked systems **310**A-D, data aggregator **325** may wait until the next time point **603** and repeat steps **501**-**509**. Additionally or alternatively, report generator **326** may, at step **510**, generate data reports in response to the data analysis queries in a manner similar to step **510** of FIG. **4**.

While the present disclosure has been shown and described with reference to particular embodiments thereof, it will be understood that the present disclosure can be practiced, without modification, in other environments. The foregoing description has been presented for purposes of illustration. It is not exhaustive and is not limited to the precise forms or embodiments disclosed. Modifications and adaptations will be apparent to those skilled in the art from consideration of the specification and practice of the disclosed embodiments. Additionally, although aspects of the disclosed embodiments are described as being stored in memory, one skilled in the art will appreciate that these aspects can also be stored on other types of computer readable media, such as secondary storage devices, for example, hard disks or CD ROM, or other forms of RAM or ROM, USB media, DVD, Blu-ray, or other optical drive media.

Computer programs based on the written description and disclosed methods are within the skill of an experienced developer. Various programs or program modules can be created using any of the techniques known to one skilled in the art or can be designed in connection with existing software. For example, program sections or program modules can be designed in or by means of .Net Framework, .Net Compact Framework (and related languages, such as Visual Basic, C, etc.), Java, C++, Objective-C, HTML, HTML/AJAX combinations, XML, or HTML with included Java applets.

Moreover, while illustrative embodiments have been described herein, the scope of any and all embodiments having equivalent elements, modifications, omissions, combinations (e.g., of aspects across various embodiments), adaptations and/or alterations as would be appreciated by those skilled in the art based on the present disclosure. The limitations in the claims are to be interpreted broadly based on the language employed in the claims and not limited to examples described in the present specification or during the prosecution of the application. The examples are to be construed as non-exclusive. Furthermore, the steps of the disclosed methods may be modified in any manner, including by reordering steps and/or inserting or deleting steps. It is intended, therefore, that the specification and examples be considered as illustrative only, with a true scope and spirit being indicated by the following claims and their full scope of equivalents.

What is claimed is:

1. A computer-implemented system for dynamic aggregation of data and minimization of data loss, the system comprising:

a memory storing instructions; and

at least one processor configured to execute the instructions for:

aggregating information from a plurality of networked systems by:

collecting a first set of data at a first time point from the networked systems, the first set of data comprising data associated with a predetermined period of time and comprising one or more central variables that are included in data associated with more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables, each of the central variables and the associated variables comprising a corresponding value;

retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables;

aggregating the first set of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables;

determining that a second subset of the networked systems is available after a gap of time; and

updating one or more timestamps corresponding to the networked systems based on the first time point; and

generating one or more data reports based on the master data structures,

wherein collecting the first set of data from the networked systems further comprises collecting a second set of data from the second subset of the networked systems, the second set of data comprising data associated with the gap of time, and

wherein aggregating the first set of data into the master data structures further comprises aggregating the second set of data into the master data structures.

2. The computer-implemented system of claim **1**, wherein the data transformation rules define how a value in the first set of data corresponds to one or more data fields of the master data structures.

3. The computer-implemented system of claim **1**, wherein a subset of the data transformation rules assigns values of one or more of the associated variables to more than one data field of the master data structures.

4. The computer-implemented system of claim **1**, wherein the processor is configured to repeat the instructions for aggregating information from the networked systems at a predetermined interval, wherein the predetermined interval is less than or equal to the predetermined period.

5. The computer-implemented system of claim **4**, wherein the predetermined interval is equal to or less than one minute.

6. The computer-implemented system of claim **1**, wherein aggregating the information from the networked systems further comprises:

determining that a first subset of the networked systems is unavailable; and

updating one or more timestamps corresponding to the networked systems,

wherein aggregating the first set of data into the master data structures omits a subset of the data transformation rules that correspond to a subset of data corresponding to the first subset of the networked systems, and

wherein updating the timestamps omits updating timestamps that correspond to the first subset of the networked systems.

7. The computer-implemented system of claim **1**, wherein aggregating the first set of data comprises:

sorting the first set of data in sequence based on time;

iterating through the sorted first set of data chronologically to replace existing values of one or more data fields in the master data structures with the values from the sorted first set of data.

8. The computer-implemented system of claim **1**, wherein the relational map is determined based on one or more data profiles of the networked systems, the data profiles comprising at least one of one or more metadata, one or more definitions of the associated variables, and a data element synonym registry.

9. The computer-implemented system of claim **1**, wherein generating the data reports comprises analyzing the master data structures to determine one or more performance metrics associated with the networked systems.

10. A computer-implemented method for dynamic aggregation of data and minimization of data loss, the method comprising:

aggregating information from a plurality of networked systems by:

collecting a first set of data at a first time point from the networked systems, the first set of data comprising data associated with a predetermined period of time and comprising one or more central variables that are included in data associated with more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables, each of the central variables and the associated variables comprising a corresponding value;

retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables;

aggregating the first set of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables;

determining that a second subset of the networked systems is available after a gap of time; and

updating one or more timestamps corresponding to the networked systems based on the first time point; and

generating one or more data reports based on the master data structures,

wherein collecting the first set of data from the networked systems further comprises collecting a second set of data from the second subset of the networked systems, the second set of data comprising data associated with the gap of time, and

wherein aggregating the first set of data into the master data structures further comprises aggregating the second set of data into the master data structures.

11. The computer-implemented method of claim **10**, wherein the data transformation rules define how a value in the first set of data corresponds to one or more data fields of the master data structures.

12. The computer-implemented method of claim **10**, wherein a subset of the data transformation rules assigns values of one or more of the associated variables to more than one data fields of the master data structures.

13. The computer-implemented method of claim **10**, wherein the processor is configured to repeat the instructions for aggregating information from the networked systems at a predetermined interval, wherein the predetermined interval is less than or equal to the predetermined period.

14. The computer-implemented method of claim **10**, wherein aggregating the information from the networked systems further comprises:

determining that a first subset of the networked systems is unavailable; and

updating one or more timestamps corresponding to the networked systems,

wherein aggregating the first set of data into the master data structures omits a subset of the data transformation rules that correspond to a subset of data corresponding to the first subset of the networked systems, and

wherein updating the timestamps omits updating timestamps that correspond to the first subset of the networked systems.

15. The computer-implemented method of claim **10**, wherein aggregating the first set of data comprises:

sorting the first set of data in sequence based on time;

iterating through the sorted first set of data chronologically to replace existing values of one or more data fields in the master data structures with the values from the sorted first set of data.

16. The computer-implemented method of claim **10**, wherein the relational map is determined based on one or more data profiles of the networked systems, the data profiles comprising at least one of one or more metadata, one or more definitions of the associated variables, and a data element synonym registry.

17. The computer-implemented method of claim **10**, wherein generating the data reports comprises analyzing the master data structures to determine one or more performance metrics of the networked systems.

18. A computer-implemented system for dynamic aggregation of data and minimization of data loss, the system comprising:

a memory storing instructions; and

at least one processor configured to execute the instructions for:

aggregating information from a plurality of networked systems by:

transmitting a data request to the networked systems at a predetermined interval;

receiving a first set of data at a first time point from a first subset of networked systems, the first subset of networked systems having a first set of corresponding timestamps from an immediately preceding time point, and the first set of data comprising data associated with a period of time between the immediately preceding time point and the first time point;

receiving a second set of data at the first time point from a second subset of networked systems, the second subset of networked systems having a second set of corresponding timestamps from a second time point older than the immediately preceding time point, and the second set of data comprising data associated with a period between the second time point and the first time point;

receiving a third set of data at the first time point from a third subset of networked systems, the third subset of networked systems having a third set of corresponding timestamps from the immediately preceding time point, and the third set of data indicating that the third subset of networked systems are not available,

wherein the first set of data and the second set of data comprise one or more central variables that are included in data from more than one networked systems of the plurality of networked systems and one or more associated variables that describe one or more aspects of the central variables;

retrieving one or more data transformation rules based on a relational map among the central variables and the associated variables;

aggregating the first and second sets of data into one or more master data structures corresponding to the central variables based on the data transformation rules, each of the one or more master data structures comprising one or more data fields that correspond to one of the central variables and a subset of the associated variables; and

updating the first and second sets of corresponding timestamps based on the first time point; and

generating one or more data reports based on the master data structures.

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